

6.0 PUGET SOUND CHINOOK SALMON ESU

6.1 BACKGROUND

6.1.1 Description of the ESU

The Puget Sound chinook salmon ESU includes all naturally spawned chinook populations residing below impassable natural barriers (e.g., long-standing, natural waterfalls) in the Puget Sound region from the North Fork Nooksack River to the Elwha River on the Olympic Peninsula, inclusive. The Puget Sound chinook salmon ESU is large and complex, comprising many individual, discrete populations spread among the major Puget Sound region watersheds. The region includes areas where the habitat still supports self-sustaining natural production of chinook, areas where habitat for natural production has been irrevocably lost, and areas where chinook salmon were never self-sustaining. In addition, the Puget Sound contains areas where indigenous local stocks persist and areas where local stocks are a composite of indigenous stocks and introduced hatchery fish that may or may not be of local origin. In some areas where natural production has been lost, hatchery production has been used to mitigate for lost natural production.

The Puget Sound Technical Recovery Team (TRT) has preliminarily delineated 22 independent populations of chinook salmon that are currently extant within this ESU (PS TRT 2003a, Table 6.1). In a separate review, the NOAA Fisheries Northwest Fisheries Science Center (NWFSC) made determinations regarding the status of chinook salmon hatchery populations within the Puget Sound chinook salmon ESU (SSHAG 2003). Through their review, the NWFSC categorized each hatchery population based on its relationship to donor or adjacent natural-origin chinook salmon populations. Hatchery populations that were determined to be genetically the same as, or only moderately diverged from the 22 natural populations delineated by the TRT were classified as “Category 1” and “Category 2” populations. Hatchery chinook populations that were judged to have diverged substantially from extant natural populations, or not to be representative of any natural population, were designated as “Category 3;” and “Category 4” populations, respectively. Hatchery populations designated as “Category 1” and “Category 2” are considered part of the Puget Sound chinook salmon ESU. These latter hatchery populations include both populations that are integrated with TRT-delineated natural populations and chinook salmon populations that are isolated from natural populations. Within-ESU hatchery chinook populations are identified in Table 6.1, and are paired with independent natural populations where the two are integrated. Hatchery populations considered not to be part of the ESU are also identified. Table 6.2 inventories Puget Sound chinook salmon hatchery programs showing ESU, whether or not integrated with the natural population, and production status for each program within the geographical boundaries of the Puget Sound chinook salmon ESU.

Table 6.1. Independent, currently extant Puget Sound chinook salmon populations delineated by the Puget Sound TRT and relationships to Puget Sound chinook salmon hatchery populations.

Independent Populations ¹	Associated Within ESU Hatchery Populations ^{2/}	Isolated Out-of-ESU Hatchery Populations ^{3/}
N.F. Nooksack	(1) Kendall Creek Hatchery	Lummi Bay Hatchery (Green R)
S.F. Nooksack	None	-
Lower Skagit	(2) Marblemount Hatchery Fall	-
Upper Skagit	(3) Marblemount Hatchery Summer	-
Upper Cascade	(4) Marblemount Hatchery Spring	-
Lower Sauk	None	-
Upper Sauk	None	-
Suiattle	None	-
N.F. Stillaguamish	(5) Harvey Creek Hatchery (6) Whitehorse Springs Hatchery	-
S.F. Stillaguamish	None	-
Skykomish	(7) Wallace River Hatchery Summer (8) Tulalip Bay Hatchery Summer	Tulalip Bay Hatchery Spring Chinook Tulalip Bay Hatchery Fall Chinook (Green)
Snoqualmie	None	
N. Lk. Washington	None	UW Portage Bay Hatchery (Green) (21) Issaquah Hatchery (Green)
Cedar	None	
Green	(9) Soos Creek Hatchery (10) Icy Creek Hatchery (11) Keta Creek Hatchery	(22) Grovers Creek Hatchery (23) Garrison Sprgs/Chambers Ck. (24) Minter Creek (25) Tumwater Falls (26) Big Beef Creek (terminated in 2004) (27) Glenwood Springs Hoodsport (Finch Creek) Hatchery Samish Hatchery
White	(12) White River Hatchery (13) White River Acclimation Ponds (14) Hupp Springs Hatchery	-
Puyallup	(15) Voights Creek Hatchery (Green) (16) Diru Creek Hatchery (Green)	-
Nisqually	(17) Clear Creek Hatchery (Green) (18) Kalama Creek Hatchery (Green)	-
Skokomish	None	George Adams Hatchery (Green R.) Rick's Pond Hatchery (Green R.)
Westside Hood Canal	None	Hamma Hamma Hatchery (½ Green)
Dungeness	(19) Dungeness Hatchery	-
Elwha	(20) Elwha Channel Hatchery	-

¹ Independent chinook salmon populations preliminarily delineated by the Puget Sound TRT for the Puget Sound chinook salmon ESU (PS TRT, July, 2003).

² Puget Sound region within ESU hatchery-origin chinook salmon populations located in watersheds where independent populations have been identified by the TRT, and that are considered integrated with, or genetically representative of, the extant natural populations.

³ Puget Sound region hatchery-origin chinook salmon populations that are not located within watersheds harboring independent chinook salmon populations delineated by the TRT (i.e., isolated). These programs propagate hatchery lineage fall chinook salmon in areas outside of the natural spawning and production range of the natural populations originally used to found the hatchery population, and are geographically and genetically disconnected from the founding hatchery lineage. Numbered populations that were designated in SSHAG (2003) as Category 2 are within ESU; non-numbered hatchery populations are considered out-of-ESU.

Table 6.2. Puget Sound chinook salmon hatchery propagation inventory. ESU, natural population integration, and production statuses for chinook salmon hatchery programs located within the geographical boundaries of the Puget Sound chinook salmon ESU.

HGMP Name	Program Type & Purpose	ESU Status *	Program Description	Program Size (Max. release/yr)	Years in Operation
<i>North Sound</i>					
Kendall Creek	Integrated Conservation	In	Eyed egg/presmolt/smolt	800,000	25
Lummi Bay	Isolated Harvest	Out	Subyearling smolt	2,000,000	26
Glenwood Springs	Isolated Harvest	Out ^{1,2}	Subyearling/yearling smolt	300,000 / 200,000	25
Samish	Isolated Harvest	Out	Subyearling/yearling smolt	4,000,000 / 100,000	90
Marblemount Spring	Integrated Research	In	Subyearling/yearling smolt	250,000 / 150,000	26
Marblemount Summer	Integrated Research	In	Subyearling smolt	200,000	10
Marblemount Fall	Integrated Research	In	Subyearling smolt	222,000	6
Harvey Creek	Integrated Conservation	In	Subyearling smolt	200,000	24
Whitehorse Pond	Integrated Conservation	In			24
Tulalip Bay Spring	Isolated Harvest	Out	Yearling smolt	40,000	11
Tulalip Bay Summer	Isolated Harvest	In	Subyearling smolt	1,500,000	6
Tulalip Bay Fall	Isolated Harvest	Out	Subyearling smolt	200,000	23
Wallace River	Integrated Harvest	In	Subyearling/yearling smolt	1,000,000 / 250,000	31
<i>Mid Sound</i>					
Issaquah	Isolated Harvest	Out ^{2/}	Subyearling smolt	2,000,000	67
Portage Bay	Isolated Research	Out	Subyearling smolt	180,000	52
Soos Creek	Integrated Harvest	In	Subyearling smolt	3,200,000	103
Icy Creek	Integrated Harvest	In	Yearling smolt	300,000	21
Keta Creek	Integrated Harvest	In	Fingerling	600,000	17
Grovers Creek	Isolated Harvest	Out ²	Subyearling/yearling smolt	2,850,000 / 150,000	26

<u>South Sound</u>					
Voights Creek	Integrated Harvest	In	Subyearling smolt	1,610,000	87
Diru Creek	Integrated Harvest	In	Subyearling smolt	400,000	25
White River	Integrated Conservation	In	Subyearling/yearling smolt	260,000 / 90,000	15
White R. Acclimation	Integrated Conservation	In	Fingerling	840,000	12
Garrison Springs	Isolated Harvest	Out ²	Subyearling smolt	820,000	28
Chambers Creek	Isolated Harvest	Out ²	Yearling smolt	300,000	6
Clear Creek	Isolated Harvest	In	Subyearling smolt	3,400,000	14
Kalama Creek	Isolated Harvest	In	Subyearling smolt	600,000	25
Minter/Coulter Fall	Isolated Harvest	Out ²	Subyearling smolt	1,835,000	58
Hupp Spgs Spring	Isolated Conservation	In	Subyearling/yearling smolt	250,000 / 85,000	30
Tumwater Falls	Isolated Harvest	Out ²	Subyearling/yearling smolt	3,800,000 / 250,000	58
<u>Hood Canal</u>					
George Adams	Isolated Harvest	Out	Subyearling smolt	3,843,000	43
Rick's Pond	Isolated Harvest	Out	Yearling smolt	250,000	9
Hoodspout/Finch Ck.	Isolated Harvest	Out	Subyearling/yearling smolt	3,000,000 / 250,000	51
Hamma Hamma	Integrated Conservation	Out	Subyearling smolt	110,000	9
Big Beef Creek	Isolated Harvest	Out ^{2/3/}	Subyearling smolt	200,000	32
<u>Strait of JDF</u>					
Dungeness/Hurd Ck.	Integrated Conservation	In	Fingerling/subyearling smolt (from captive broodstock)	2,000,000	12
Elwha Channel	Integrated Conservation	In	Subyearling	3,850,000	51 (90)

* SSHAG (2003) recommendations, unless otherwise indicated (see footnotes).

¹ The founding and continuing broodstock source for Glenwood Springs Hatchery is Samish Hatchery, which propagates an out-of-ESU population.

² These populations were founded through transfers of Green River hatchery lineage fall chinook salmon into watersheds where no native chinook population existed, and where habitat features needed to sustain a natural chinook population are lacking. The populations are sustained by juvenile hatchery releases, lead to the production of no to few natural-origin adults, and remain geographically, ecologically, and genetically disconnected from the extant Green River hatchery population(s) originally used to found them. No measures have ever been applied in the hatchery programs to maintain the ecological and genetic characteristics of the Green River natural, hatchery, or hatchery-lineage populations.

³ The founding and, through 1993, annual broodstock sources for Big Beef Creek Hatchery were George Adams and Hoodspout hatcheries which propagate out-of-ESU populations.

6.1.2 Status of Puget Sound Chinook Salmon ESU Natural Populations

In its most recent review of the ESA status of the Puget Sound chinook salmon ESU, the majority of BRT members found that the ESU remains “likely to become endangered” in status (NMFS 2003). General “Viable Salmonid Population” (VSP) parameter findings for the naturally spawning populations within the ESU were provided in the updated BRT status review document (NMFS 2000). In summary, the BRT found moderately high risks for the chinook ESU in all VSP elements (Table 3).

The BRT expressed concern for the high levels of hatchery chinook salmon production in many areas of the ESU (NMFS 2003). With the exception of the Skagit and Stillaguamish river basins, the BRT reported that all major watersheds in Puget Sound receive annual releases of over a million juvenile chinook salmon. The BRT thought that only 2 of the 22 extant chinook salmon populations within the ESU have a low fraction of hatchery-origin fish comprising annual adult escapement. In NMFS’ previous status review for the Puget Sound chinook ESU, the pervasive use of Green River-origin fall chinook salmon as broodstock for fisheries enhancement hatcheries throughout the ESU was cited as a potential risk factor (for reduction of genetic diversity and fitness of naturally spawning populations; Myers et al., 1998). As noted in the above summary of NMFS (2003), the change in diversity in the ESU from historical conditions has not changed since the last status review.

The widespread use of hatcheries as a means to enhance adult chinook salmon returns complicates the ability to evaluate the status of natural populations within the ESU. In particular, the inability in most watersheds to differentiate natural and hatchery-origin adult chinook salmon in natural spawning areas confounded the BRT’s assessment of past and recent year abundance and productivity for many natural populations within the ESU. Estimates of the fraction of natural spawners of hatchery-origin were found by the BRT to be sparse, with data available for only twelve of the 22 populations. Hatchery versus natural-origin chinook salmon data for the twelve populations were available for only the most recent 5 to 10 years. “Masking” of the status of natural chinook by hatchery production was also identified in NMFS’ previous status review (Myers et al. 1998). The Puget Sound salmon resource co-managers have since implemented mass marking of all hatchery chinook salmon produced in the region as a measure to allow for identification of hatchery-origin adult fish in natural spawning areas. The 2003 return year was the first when mass marked hatchery-origin four-year-old chinook salmon returned for most Puget Sound Hatchery programs managed by WDFW.

The BRT acknowledged that some hatchery reforms implemented since the last status review (including elimination of marine net-pen release programs and transition of other programs to more local broodstocks) should help facilitate recovery if other limiting factors, especially habitat degradation, were also addressed (NMFS 2003).

Table 3. General Viable Salmonid Population (VSP) parameter findings reported by the Puget Sound Chinook Salmon BRT for naturally spawning chinook salmon populations (NMFS 2003).

VSP Parameter	BRT Finding
Abundance	<p>Overall, the natural spawning escapement estimates for Puget Sound chinook salmon populations are improved relative to those at the time of the previous status review of Puget Sound chinook salmon (conducted with data through 1997). The differences between population escapement estimates between the previous status review and the present assessment (conducted with data through 2002) could be due to (1) revised pre-1997 data, (2) differences in which fish are counted as part of a population, (3) new information on the fraction of natural spawners that are hatchery fish, or (4) true differences reflected in new data on natural spawners obtained over the most recent 5 years. The median across populations of the most recent 5-year geometric mean natural escapement for the same 22 populations through 1997 was $N = 438$ (compared to $N = 771$ through 2002), and the range across the 22 populations was 1-5,400. As at the time of the previous status review, it is not possible to determine the status of the natural-origin, natural spawners in half of the populations of chinook salmon in Puget Sound due primarily to a lack of information regarding the fraction of hatchery fish that are spawning naturally.</p>
Spatial Structure	<p>The spatial distribution of chinook salmon populations with a strong component of natural-origin spawners in the Puget Sound ESU has not changed since the time of the last status assessment. Populations containing significant numbers of natural-origin spawners whose status can be reliably estimated occur in the Skagit River Basin, the South Fork Stillaguamish, and the Snohomish River Basin. The remaining populations in mid- and south Puget Sound, Hood Canal and out the Strait of Juan de Fuca have significant (but non-quantifiable) fractions of hatchery-origin spawners, so it is not possible to estimate their contribution to spatial structure.</p>
Diversity	<p>The change in diversity in the ESU from historical conditions also has not changed since the last status review. An estimated 31 independent populations of chinook salmon occurred historically in the ESU and 22 remain extant. All but one of the 9 putatively extinct chinook salmon stocks is an early-run population (or component of a population). The loss of early-run chinook salmon stocks in Puget Sound represents an important loss of part of the ESU's evolutionary legacy.</p>
Productivity	<p>Throughout the ESU, the estimates of trends in natural spawning escapements for Puget Sound chinook salmon populations are similar to the previous status (conducted with data through 1997). Some populations exhibit improvements in trends and others show more significant declines. The median across populations of the long-term trend in natural spawners was a 1.1% decline per year through 1997, compared to a median estimate indicating a flat trend through 2002. Short-term trends are generally more positive in recent years—the median trend across 22 populations through 1997 was a 4% decline per year, and the median trend through 2002 was a 1.1% increase per year. Information is lacking on the fraction of naturally spawning, hatchery-origin fish for 10 of the 22 populations of chinook salmon in Puget Sound, so the BRT's understanding of the trend in natural-origin spawners among populations across the ESU is incomplete.</p>

6.2 CHINOOK SALMON ARTIFICIAL PROPAGATION EFFECTS ON THE STATUS OF THE PUGET SOUND CHINOOK SALMON ESU

NMFS applies its proposed Hatchery Listing Policy to the BRT's status review findings to derive preliminary conclusions regarding the effects of individual chinook salmon hatchery programs on the status of natural populations within the geographical boundaries of the Puget Sound chinook salmon ESU. These conclusions are based on assessments of hatchery broodstock and program histories, similarities between hatchery origin and natural origin fish, hatchery program designs, program performance, and program compliance with the best management practices summarized in Appendix I. Each hatchery program's effects on VSP parameters for the appropriate "reference" independent natural-origin chinook salmon population are also provided. These summaries are based on more detailed information regarding VSP parameter effects of the individual programs presented in Appendix II, which describe influences on the abundance, diversity, spatial structure, and productivity of the reference natural chinook salmon populations. The evaluation of each hatchery program concludes with the NMFS' NWR pre-decisional perspective regarding changes to existing artificial propagation practices that could be implemented in the future to improve the contribution of the hatchery program to the viability of natural populations.

6.2.1 Kendall Creek Hatchery Spring Chinook

6.2.1.1 Broodstock/Program History. The program was initiated in 1981 for the purpose of preserving and increasing the abundance of the native spring chinook salmon population in the North Fork Nooksack River, which had declined to critically low abundance levels (WDFW 2003a; SaSI 2003). Broodstock collection and juvenile fish production practices have evolved since to reduce the risks to natural-origin spring chinook in the watershed. Other adjustments in the program, including reduction in on-station juvenile fish release levels, and dispersal of an increased proportion of the total production into up-river acclimation sites, should benefit the viability of the North Fork Nooksack natural spring chinook population. These same actions should reduce genetic introgression risks to the neighboring South Fork Nooksack spring chinook population, which has been affected by straying of Kendall Creek Hatchery spring chinook adults into natural spawning areas.

Native spring chinook broodstock used to establish the program were gill-netted in Wicks Slough, a Clearwater North Fork Nooksack tributary near the hatchery. Adult fish collected in Wicks Slough were transferred to Kendall Creek Hatchery for spawning and production of predominately subyearling fish for release at the hatchery. The objective of the program was to establish an adult spring chinook return to Kendall Creek to sustain the conservation program, avoiding the need to collect broodstock from the depressed natural population. The spring chinook salmon adult return established at Kendall Creek Hatchery is now collected for use as broodstock using the hatchery weir and trap (WDFW 2003a). Although as a conservation program derived from the native population natural-origin fish are not incorporated, the program is considered integrated with the natural population.

6.2.1.2 Similarity of Hatchery Origin to Natural Origin Fish. Genetic analysis of natural origin and Kendall Creek Hatchery-origin spring chinook indicate that there are no significant differences between the natural and hatchery populations, and that they are one distinct stock (Young and Shaklee 2002; SaSI 2003). The hatchery population is currently listed under the ESA with its founding North Fork Nooksack River natural population, and with other natural-origin populations in the ESU. Hatchery-origin and natural-origin spring chinook salmon share identical life history characteristics for the majority of the natural chinook salmon life cycle, including: seaward emigration in the Nooksack River (Conrad and MacKay 2000; MacKay 2000 –hatchery-origin juveniles are released during the April-June period when natural-origin fry are emigrating seaward); early rearing in the nearshore marine areas of North Puget Sound; emigration northward into southern British Columbia marine waters; rearing for two to five years from smolt-to-adult size in Northeast Pacific marine waters; migration through British Columbia and Washington marine waters as maturing two to five year old adults in the spring and early summer months; and freshwater entry and spawning in the Nooksack River watershed in May through September (SaSI 2003; WDFW 2003a). On the other hand, the hatchery-origin fish are artificially spawned, and their progeny are incubated and reared in a hatchery under controlled conditions rather than being deposited as eggs in gravel reaches and rearing to smolt size in the natural environment. Monitoring and evaluation of the genetic and ecological effects of the program are ongoing (WDFW 2003a; Conrad and MacKay 2000; MacKay 2000), and these data will be used to adjust the hatchery program to meet its fish production and conservation objectives (WDFW 2003a; Kirby 2003).

6.2.1.3 Program Design. The program is specifically designed to preserve the native North Fork Nooksack spring chinook population, increasing prospects for its recovery to a viable, self-sustaining level. The program has been successful in increasing the number of naturally spawning spring chinook salmon in the North Fork Nooksack River (WDFW 2003a; Castle et al., 2002). Adults originating from the program have comprised greater than 50 percent of the total naturally spawning population since 1996 (Castle et al., 2002). Mass marking of hatchery spring chinook with coded wire tags and using otolith marks has allowed for assessments to be made of stray levels of hatchery fish to watersheds outside of juvenile fish release sites. Most returning adults have been recovered in the North Fork Nooksack River basin (Castle et al., 2002; Kirby). However, a proportion of the annual adult returns were also recovered in the South Fork Nooksack River. An estimated 24 percent to 44 percent of the total number of spring chinook spawners in the South Fork Nooksack River in 1999-2001 were strays, predominately from the Kendall Creek Hatchery program (Kirby 2002).

Best management practices are applied in program implementation, and most are consistent with the measures described for integrated programs in Appendix I and with the conservation hatchery practices proposed in Flagg and Nash (1999). However, natural spring chinook are not presently incorporated as broodstock, as a measure to prevent removal (mining) of the critically depressed natural origin fish from remaining spawning areas. Specific measures implemented to minimize adverse genetic, ecological, and demographic effects on listed fish, including those

under propagation at the hatchery, are included in the Kendall Creek Hatchery HGMP, which describes hatchery fish production, monitoring and evaluation, and research actions (WDFW 2003a). Sections 6, 7, 8, and 9 of the HGMP describe broodstock selection, collection, mating, and juvenile fish rearing measures that will be applied to minimize the risk of within and among population diversity loss to the donor listed, and artificially propagated, spring chinook salmon population. Measures implemented to minimize ecological effects on listed natural populations are described in HGMP sections 7.7, 9.3, 9.16, 9.17, 9.27, 10.9, and 11.1. All juvenile fish released through the program are marked through thermally induced otolith banding and/or with coded wire tags. Juvenile emigrant trapping is conducted to assess the productivity of the naturally spawning spring chinook populations in the Nooksack River watershed (Conrad and MacKay 2000; MacKay 2000).

6.2.1.4 Program Performance. Adult returns from the hatchery program comprised an average of 91 percent of the total spring chinook return to the North Fork Nooksack River basin from 1995 through 2001 (data from Castle et al., 2002). For 1988 to 1995, the smolt-to-adult survival rate for fish released from the hatchery averaged 0.4 percent, and ranged from 0.04 percent to 1.5 percent (WDFW 2003a). Recruit per spawner rates based on mark recovery data in natural spawning areas indicates that the natural population is not replacing itself. Brood year 1992-1996 recruit per spawner rates averaged 0.3 and ranged from 0.14 to 0.4 (Castle et al., 2002). The program is planned to continue indefinitely, or until habitat features necessary for the re-establishment of a viable, self-sustaining natural population are restored. The hatchery weir on Kendall Creek blocks upstream migration of salmon. Water intake screening for the hatchery is in compliance with NMFS screening criteria (WDFW 2003a; NMFS 1995, 1996).

6.2.1.5 VSP Effects. This conservation-directed program may provide substantial benefits to VSP parameters for the North Fork Nooksack spring chinook salmon population, a unique population that will likely be considered important for recovery of the Puget Sound chinook salmon ESU to a viable level. The program likely benefits the abundance, diversity, and spatial structure of the population. NMFS (2003) reported a 1998-2002 geometric mean natural spawner escapement for the North Fork Nooksack population of 1,538 fish. This average figure included surplus hatchery adults planted back into the natural environment from Kendall Creek Hatchery. The mean number of natural-origin spawners for this period was estimated to be 125. The remainder of the mean number of natural spawners, 1,413 fish or 92 percent of the mean escapement to the spawning area, were Kendall Creek Hatchery-origin spring chinook. The 1997-2001 arithmetic mean total spawner escapement to Kendall Creek Hatchery is 2,645 adult fish (excludes jacks) (WDFW 2003a). Measures are applied through the Kendall Creek Hatchery program to maintain the diversity of the propagated population. Broodstock are collected randomly over the breadth of the return, a high effective breeding population size has been maintained ($N_e = 4,330$ for 1997-2001), and a factorial mating scheme is used during spawning (WDFW 2003a). On-station release numbers and proportions have been reduced, and the dispersal of hatchery production into acclimation ponds and egg boxes located in upper North Fork and Middle Fork Nooksack tributaries where natural fish were historically present (Castle et al., 2002; Kirby 2003) benefits population spatial structure. The program's effects on

productivity are unknown, but the continuing low numbers of natural-origin spawners suggests that productivity in the extant natural habitat remains poor, and that contributions by naturally spawning hatchery fish are not leading to improved productivity. NMFS (2003) reported a short term (1990-2002) median population growth rate (λ) for the composite (hatchery and natural chinook) North Fork Nooksack population of 0.75. In developing this estimate, NMFS assumed that the reproductive success of naturally spawning hatchery fish was equivalent to that of natural fish. The composite North Fork Nooksack naturally spawning population is not replacing itself in the short term, despite decades of high contributions of hatchery-origin spawners through straying. Long and short term population trends estimated for all spawners were 1.16 and 1.42 respectively (NMFS 2003).

6.2.2 Lummi Bay Hatchery Fall Chinook

6.2.2.1 Broodstock/Program History. Lummi Bay Hatchery has released transplanted Green River hatchery-lineage fall chinook salmon juveniles into Lummi Bay and into the lower Nooksack River since 1978. Recent adjustments to the program include reductions in annual juvenile fish release levels, mass and differential marking of subyearlings released at the two planting locations, and planning for on-site broodstock collection rather than transfers from other hatchery locations. If stray levels for adult fall chinook into Nooksack River natural production areas are shown to be detrimental to the native populations, program changes that would reduce the risk to natural chinook viability could include reducing juvenile fish release levels, changing fish release locations, and changing the broodstock to one of native, local origin.

The hatchery population propagated through the program originated and is currently transplanted from WDFW's Samish Hatchery. The hatchery fall chinook stock is not native to the Nooksack River watershed, and it is designed to be isolated from native populations in that watershed. The transplanted, isolated hatchery population is not part of the Puget Sound chinook salmon ESU.

6.2.2.2 Similarity of Hatchery Origin to Natural Origin Fish. The hatchery population propagated through the program is considered to be substantially diverged from natural chinook populations in Puget Sound (SSHAG 2003) and out of the ESU. Genetic sampling of the fall chinook population propagated through the program (Samish Hatchery) and the program's stock transfer history indicate that fish from the program are related to other transplanted Green River lineage hatchery populations, and distinct from native Nooksack River basin chinook populations (Marshall et al., 1995; SaSI 2003; Young and Shaklee 2002).

6.2.2.3 Program Design. The Lummi Bay Hatchery program is designed to provide salmon for harvest at times and in areas isolated from natural chinook salmon populations. Recent releases have been 100 percent adipose fin clipped, with a percentage also receiving coded wire tags prior to release. Best management practices are applied as detailed in the HGMP for the program (Lummi 2003). Hatchery practices are generally consistent with measures described for isolated programs in Appendix I.

6.2.2.4 Program Performance. Although the program is designed to be isolated from natural chinook populations, it is likely that returning adults produced by the program stray into the Nooksack River watershed (Kirby 2002; Young and Shaklee 2002). Juvenile fish released through the program are now mass marked with adipose fin clips and differential coded wire tags, which will allow for stray rate assessments to be completed through planned spawning ground surveys (Lummi 2003).

6.2.2.5 VSP Effects. As operated, the program is expected to have neutral to slightly negative effects on native Nooksack River spring chinook populations. Juvenile fall chinook from the program are released in marine or intertidal areas adjacent to the mouth of the Nooksack River. Monitoring and evaluation results of straying are needed to determine whether straying and genetic introgression are valid risk factors, necessitating program reform. Program juvenile fish are mass and differentially marked to provide for monitoring. VSP parameters for natural-origin Green River fall chinook (the reference population for this program) and for Nooksack River spring chinook do not benefit from this program, as the hatchery stock is substantially diverged from, and not representative of, any extant Puget Sound chinook population. It is designated as an out-of-ESU stock (SSHAG 2003).

6.2.3 Samish Hatchery Fall Chinook

6.2.3.1 Broodstock/Program History. Since 1914, WDFW's Samish Hatchery has released mainly transplanted Green River hatchery-lineage fall chinook salmon juveniles into the Samish River where no chinook salmon population previously existed. Recent adjustments to the program include reduction in annual juvenile fish release levels, mass and differential marking of subyearlings released at the two planting locations, and planning for on-site broodstock collection rather than transfers from other hatchery locations. If stray levels for returning adult fall chinook into natural chinook production areas in neighboring watersheds are shown to be detrimental to native populations, program changes that would lead to decreased risk to natural chinook salmon viability could include reducing juvenile fish release levels, changing fish release locations, and changing the broodstock used in the program to one that is of native, local origin.

The hatchery population propagated through the program originated from WDFW's Soos Creek Hatchery. Green River-origin chinook eggs were first transferred to Samish Hatchery in 1929, supplanting Columbia River-origin eggs as the source of fall chinook production for the facility (WDFG 1932). A consistent year-to-year chinook salmon egg transfer program from Soos Creek Hatchery to Samish Hatchery began in 1938, in an attempt to create a return to Samish Hatchery that could sustain the hatchery program (WDF 1938). No chinook eggs were taken from broodstock returning to Samish prior to 1937 (WDF 1939; 1941). Transfers of Green River hatchery lineage fall chinook from other WDFW hatcheries in the region continued through the early 1990s as needed to meet on-station production objectives (WDFW 2003c). The hatchery fall chinook stock propagated in the Samish program is not native to the North Puget Sound region, and it is designed to be isolated from native populations in neighboring watersheds. The

transplanted, isolated hatchery population is not part of the Puget Sound chinook salmon ESU.

6.2.3.2 Similarity of Hatchery Origin to Natural Origin Fish. The Samish River does not have a native self-sustaining chinook salmon population (SaSI 2003; PS TRT 2003) and chinook returns were introduced, and are sustained, by hatchery production. Genetic sampling of the fall chinook population propagated through the program and the program's stock transfer history indicate that the hatchery fish are related to other transplanted Green River lineage hatchery populations, and distinct from neighboring natural chinook salmon populations, including the Nooksack River basin and Skagit River basin chinook populations (Marshall et al., 1995; SaSI 2003; Young and Shaklee 2002; WDFW 2003b; 2003c).

6.2.3.3 Program Design. The program is designed to provide chinook salmon for commercial and recreational fisheries harvest. The chief fishery benefiting from the program occurs in Bellingham Bay at times and in areas isolated from natural chinook salmon populations. Subyearling and yearling fall chinook releases have been 100 percent adipose fin clipped, with a percentage also given coded wire tags before release. Best management practices are applied as detailed in the Samish Hatchery HGMPs (WDFW 2003b; 2003c). Hatchery practices are generally consistent with measures described for isolated programs in Appendix I.

6.2.3.4 Program Performance. Although the program is designed to be isolated from natural chinook populations, returning adults produced by the program stray and spawn at substantial levels in the Nooksack River watershed (SaSI 2003; Young and Shaklee 2002). Juvenile fish released through the program are now mass marked with adipose fin clips and differential coded wire tags, which will allow for improved stray rate assessments for this specific fall chinook program to be completed through planned spawning ground surveys by the co-managers in the north Puget Sound region (WDFW 2003b; 2003c). WDFW proposes that the program be operated indefinitely to provide fall chinook for harvest. The average smolt-to-adult survival rates for subyearlings (1994-98 brood years) and yearlings (1994 and 1995) released through the program are 0.48 percent and 0.04 percent respectively (WDFW 2003b; 2003c). A weir used to collect fall chinook for use as broodstock blocks fish migration at river mile 1.0 on the Samish River. A fish-way, which allows for fish passage at the hatchery water intake location on Friday Creek, is being renovated to improve passage success (WDFW 2003b; 2003c). Screening at the water intake is not in compliance with NMFS screening criteria, but WDFW is replacing the screening to meet criteria for the protection of juvenile natural-origin fish (WDFW 2003b).

6.2.3.5 VSP Effects. The Samish Hatchery program is expected to have a neutral effect on Nooksack River spring chinook and other TRT delineated populations in the north Sound sub-region. Production from the program has recently been reduced, and the program is located in a moderately sized watershed that historically lacked a chinook salmon population. Returns to the river were established beginning in 1929 using transplanted Soos Creek Hatchery stock. VSP parameters for natural-origin Green River fall chinook (the reference population) do not benefit from this program, as the hatchery stock is substantially diverged from, and not representative of, any extant Puget Sound chinook population. It is designated as an out-of-ESU stock (SSHAG

2003). Monitoring and evaluation are needed to determine whether straying and genetic introgression are risk factors to neighboring natural populations, necessitating program reforms. If stray levels for returning adult fall chinook appear high in Nooksack River or other natural production areas, program changes that would lessen risks to natural chinook salmon viability could include reduction of juvenile fish release levels, or a change in the broodstock used in the program to one that is of native, local origin.

6.2.4 Glenwood Springs Hatchery Fall Chinook

6.2.4.1 Broodstock/Program History. The hatchery program was founded in 1979 using transplanted Samish Hatchery broodstock (WDFW 2003d), and the program is sustained, when on-station adult returns are insufficient, through annual transfers of the progeny of Green River hatchery lineage fall chinook salmon from Samish. The program is located in an area where no native chinook population existed, and where habitat features needed to sustain a natural chinook population are absent (and were not historically present). The population is sustained by juvenile hatchery releases, and there is no natural spawning by hatchery fish at the location. The program is geographically, ecologically, and genetically disconnected from the extant Green River natural and hatchery population(s) originally used to found the Samish Hatchery program, the donor stock for the Glenwood Springs program. There has been no or little use of natural-origin fish in the hatchery broodstocks, especially no Green River Basin wild chinook, which differentiates them, and should cause higher divergence, from their Green River ancestry (A. Marshall, WDFW, pers. comm., April 2004). No measures have ever been applied in the hatchery program to maintain the ecological and genetic characteristics of the Green River natural, hatchery, or hatchery-lineage populations. Consistent with the status of the donor Samish Hatchery population, the transplanted, isolated hatchery population propagated at Glenwood Springs Hatchery is not considered to be part of the Puget Sound chinook salmon ESU.

6.2.4.2 Similarity of Hatchery Origin to Natural Origin Fish. The hatchery population propagated through the program (the founding and continuing donor stock is the Samish Hatchery population) is considered to be substantially diverged from natural chinook populations in Puget Sound (SSHAG 2003) and out of the ESU. The San Juan Island region where the program is located does not have a native self-sustaining chinook salmon population (SaSI 2003; PS TRT 2003). Chinook returns were introduced and are sustained by hatchery production. Genetic sampling of the fall chinook population propagated through the program (Samish Hatchery stock) and the program's stock transfer history indicate that the hatchery fish are related to other transplanted Green River lineage hatchery populations, and distinct from neighboring natural chinook salmon populations, including the Nooksack River basin and Skagit River basin chinook populations (Marshall et al., 1995; SaSI 2003; Young and Shaklee 2002; WDFW 2003d).

6.2.4.3 Program Design. The program is designed to provide chinook salmon for recreational and commercial fisheries harvest opportunities. The predominant fisheries benefiting from the program occur in the marine waters off San Juan Island, which are isolated from natural chinook

salmon populations. Subyearling and yearling fall chinook releases are now 100 percent adipose fin clipped prior to release (WDFW 2003d). Best management practices are applied to produce adult fish for isolated harvest purposes, as detailed in the Glenwood Springs HGMP (WDFW 2003d). Hatchery practices are generally consistent with measures described for isolated programs in Appendix I.

6.2.4.4 Program Performance. The program intent is to isolate hatchery production from natural chinook populations. The location of the hatchery program in an area well removed from natural chinook populations, and data indicating that past stray levels have been very low, suggest that the program is performing as intended (WDFW 2003d). Juvenile fish released through the program are now mass marked with adipose fin clips, but the lack of coded wire tags will prevent future assessments of stray rates into natural spawning areas (WDFW 2003d). WDFW proposes that the program be operated indefinitely to provide fall chinook adults for harvest opportunities. There are no passage problems (blockages or screens) associated with the program that harm natural chinook salmon populations.

6.2.4.5 VSP Effects. Because of its location (Orcas Island) and geographic isolation from natural chinook production areas, the program is expected to have a neutral effect on VSP parameters for Nooksack River basin, and other TRT delineated populations native to the north Sound sub-region. The reference population for this stock is Green River. The program is unlikely to benefit total abundance of the natural-origin Green River stock present within the ESU, as there is no spawning habitat at the hatchery site and straying appears minimal. The stock is localized to the NPS region, has been geographically isolated from the Green River population since its inception in 1979, and has relied solely on hatchery-origin fish as broodstock including (through 2003) regular infusions of Samish Hatchery fall chinook, which is considered an out-of-ESU population (SSHAG 2003). No measures have been applied in the program to maintain the genetic or ecological characteristics of the original founding Green River-derived hatchery stock. Like the donor Samish Hatchery population, the Glenwood Spring Hatchery population is considered to be a substantially diverged population, and not part of the listed ESU. The program is unlikely to benefit any VSP parameters for extant natural Puget Sound chinook salmon populations.

6.2.5 Marblemount Hatchery Spring Chinook

6.2.5.1 Broodstock/Program History. The program was initiated in 1978 for the purpose of increasing the abundance of spring chinook salmon in the Skagit River Basin and creating an indicator stock for assessing natural-origin Skagit River spring chinook harvest impacts in Pacific Northwest fisheries (WDFW 2003e, 2003f; SaSI 2003). Broodstock collection and juvenile fish production practices have evolved since initiation of the program to reduce the risks to natural-origin spring chinook in the Skagit River watershed. Adjustments in the program, including use of a native origin (mainly Suiattle River), localized spring chinook stock for propagation in the program should reduce genetic introgression risks to the neighboring spring chinook population in the Cascade River.

Native Suiattle River spring chinook broodstock was used to establish the program in 1974 through adult fish collections from Buck Creek, a Suiattle tributary, later from other tributaries of the Suiattle River (WDFW 2003e). In 1981, the first returns of Buck Creek stock returned to Marblemount Hatchery. These progeny, along with the other tributary broods were combined through spawning and rearing and released to create an adult return to Marblemount Hatchery. Only hatchery-origin spring chinook are presently used as broodstock. The spring chinook salmon adult return established at Marblemount Hatchery is now collected for use as broodstock using the hatchery weir and trap (WDFW 2003e). Although natural-origin fish are not incorporated, hatchery broodstock were derived from the native population, and the program is considered representative of and integrated with the natural spring chinook population in the upper Skagit River watershed.

6.2.5.2 Similarity of Hatchery Origin to Natural Origin Fish. The hatchery broodstock was founded primarily from natural Skagit River Basin spring chinook populations, but only hatchery-origin adults have been used since the mid-1990s (WDFW 2003e). Given its production history, the hatchery population may be diverged from the founding population; primarily Buck Creek in the Suiattle watershed. Genetic analyses indicate that the native Cascade River spring chinook population is significantly different from the Marblemount Hatchery spring chinook population (Marshall et al., 1995). Hatchery fish stray at low levels in the lower 2.5 miles of the Cascade River (Marshall et al., 1995), which may pose an unknown level of risk of genetic introgression. Hatchery-origin and natural-origin spring chinook salmon in the watershed share identical life history characteristics for the majority of the life cycle, including: seaward emigration as subyearling and yearling smolts in the Cascade and mainstem Skagit rivers (Seiler et al., 2000, 2001, 2002—hatchery-origin fish are released during April-June, when natural-origin spring chinook smolts are also emigrating seaward); early rearing in Skagit River delta freshwater and estuarine, and North Puget Sound nearshore marine areas; emigration northward through Washington and British Columbia marine waters; rearing for two to five years from smolt-to-adult size in Northeast Pacific marine waters; migration through British Columbia and Washington marine waters as maturing two to five year old adults in the spring and early summer months; and freshwater entry and spawning in the Skagit River watershed in May through September (SaSI 2003; WDFW 2003e). On the other hand, the hatchery-origin fish are artificially spawned, and their progeny are incubated and reared for five months to one year under controlled conditions rather than being deposited as eggs in gravel reaches and rearing to smolt size in the natural environment. Monitoring and evaluation of the genetic and ecological effects of the program are ongoing (WDFW 2003e; 2003f; and for e.g., Seiler et al., 2002), and data collected will be used to adjust the hatchery program to meet its fish production and research objectives (WDFW 2003e; 2003f).

6.2.5.3 Program Design. The program is designed to increase the abundance of spring chinook salmon representative of populations native to the upper Skagit River watershed for harvest augmentation and stock assessment purposes. The program has been successful in increasing the number of spring chinook salmon returning to Marblemount Hatchery (WDFW 2003a; Castle et

al., 2002). Most returning adults are recovered at Marblemount Hatchery, but a proportion of the annual hatchery adult returns are also recovered in the lower Cascade River (Marshall et al., 1995). WDFW estimates that stray rates of Marblemount Hatchery subyearling spring chinook into natural spawning areas are low relative to the total annual return (modeled to be 0.21 percent of the annual return; WDFW 2000e).

Best management practices are applied in implementing the program, and most are consistent with measures described for integrated programs in Appendix I. The exception is that natural spring chinook are not incorporated as broodstock as a measure to prevent removal (mining) of natural origin spring chinook from adjacent spawning areas. Specific measures implemented to minimize adverse genetic, ecological, and demographic effects on listed fish, including those under propagation at the hatchery, are included in the Marblemount Hatchery HGMPs, which describe hatchery fish production, monitoring and evaluation, and research actions (WDFW 2003e; 2003f). Sections 6-9 of the HGMPs describe broodstock selection, collection, mating, and juvenile fish rearing measures that will be applied to minimize the risk of within and among population diversity loss to the donor listed, and artificially propagated spring chinook salmon population. Measures implemented to minimize ecological effects on listed natural populations are described in appropriate sections of the HGMPs. All juvenile fish released through the program are marked with coded wire tags. Juvenile emigrant trapping is conducted to assess the productivity and migration behavior of the naturally spawning spring chinook populations, and the post-release emigration behavior and survival of hatchery chinook populations, in the Skagit River watershed (Seiler et al., 2000, 2001, 2002).

6.2.5.4 Program Performance. Adults originating from the program have recently comprised 87 percent of the five year (1995-99) average proportion of the total adult return to the Cascade River watershed (data from WDFW 2003e). Subyearling smolt-to-adult survival rates in recent years have averaged approximately 0.35 percent (WDFW 2003e). The 1987-95 smolt-to-adult survival rate for yearling spring chinook released through the program averaged 0.56 percent (WDFW 2003f). Escapement abundance trends calculated from limited mark recovery data in natural spawning areas indicates that the productivity of natural spring chinook populations is low, with rates at or below replacement levels (preliminary data from PS TRT, April 2004). The program is planned to continue indefinitely. Screening at the hatchery water intake is in compliance with NMFS' criteria (WDFW 2003e; NMFS 1995, 1996).

6.2.5.5 VSP Effects. The program may have a neutral to slightly negative effect on Skagit River basin spring chinook, and other TRT delineated populations in the North Puget Sound sub-region. The program may help preserve the abundance of a mixed-lineage spring chinook population that is similar to its primary founding population from the Suiattle River watershed (Buck Creek). NMFS (2003) reported a 1998-2002 geometric mean natural spawner escapement for the Upper Cascade River population of 274 fish. The recent year (1997-2001) arithmetic mean hatchery-origin spring chinook escapement to the hatchery was 1,618 adult fish (WDFW 2003e). The program uses only hatchery-origin fish as broodstock that are originally of Suiattle stock origin. The hatchery population is genetically different from the reference natural Cascade

River population that is native to the watershed where the hatchery is located. An estimated 0.3 percent (~1 fish) of the mean naturally spawning population abundance was estimated as being comprised by hatchery origin chinook (NMFS 2003). No genetic baseline exists as yet for the Cascade River spring chinook population to gauge genetic risks posed by the program, but low stray rates indicate that risks may be small (Marshall et al. 1995). The spatial structure of the Cascade River population is not being enhanced by the hatchery program because adult fish return to the hatchery release site and are removed. Straying into Cascade River natural spawning areas occurs at low levels (NMFS 2003; Marshall et al. 1995) and benefits to natural Cascade River spring chinook productivity are unlikely. NMFS (2003) reported a short term λ for the Upper Cascade River population of 1.06. Long and short term population trend estimates for the naturally spawning population were 1.04 and 1.05 respectively (NMFS 2003). Survival rates to adult return for Marblemount Hatchery subyearling and yearling chinook salmon are slightly below (subyearlings) or well below (yearlings) rates expected for these life stages for Puget Sound region hatcheries.

6.2.6 Marblemount Hatchery Summer Chinook

6.2.6.1 Broodstock/Program History. The program was initiated in 1994 for the purpose of creating a mass marked indicator stock for assessment of natural-origin Upper Skagit summer chinook harvest impacts in Pacific Northwest fisheries (WDFW 2003g; SaSI 2003). The program is modest in size (150 adult fish are collected from the mainstem river to produce 200,000 subyearlings), and given its research intent, adverse effects on the natural summer chinook population are not likely to be substantial.

Natural Upper Skagit summer chinook adults are collected from mainstem river natural spawning areas each year for use as broodstock, so the hatchery and natural populations are the same. Hatchery broodstock are derived from the native population, and the program is considered representative of and integrated with the natural Upper Skagit summer chinook population.

6.2.6.2 Similarity of Hatchery Origin to Natural Origin Fish. Hatchery broodstock is collected annually from the returning Upper Skagit summer chinook run in the mainstem river (WDFW 2003g). There are no genetic differences between the hatchery and natural populations. Hatchery-origin and natural-origin summer chinook salmon in the watershed share identical life history characteristics for the majority of the natural chinook salmon life cycle, including: seaward emigration as subyearlings in the mainstem Skagit River (Seiler et al., 2000, 2001, 2002—hatchery-origin fish are released during May-June, when natural-origin summer chinook subyearling smolts are also emigrating seaward); early rearing in Skagit River delta freshwater and estuarine and North Puget Sound nearshore marine areas; emigration northward as smolts through Washington and British Columbia marine waters; rearing for two to five years from smolt-to-adult size in Northeast Pacific marine waters; migration through British Columbia and Washington marine waters as maturing two to five year old adults in the spring and early summer months; and freshwater entry and spawning in the Upper Skagit River watershed in

August through September (SaSI 2003; WDFW 2003g). On the other hand, the hatchery-origin fish are artificially spawned, and their progeny are incubated and reared for approximately five months in a hatchery under controlled conditions, rather than being deposited as eggs in gravel reaches and rearing to emigrating fry or smolt size in the natural environment. Monitoring and evaluation of the genetic and ecological effects of the program are ongoing (WDFW 2003g; and for e.g., Seiler et al., 2002), and the data will be used to adjust the hatchery program to meet its fish production and research objectives (WDFW 2003g).

6.2.6.3 Program Design. The program is designed to create a fully integrated surrogate for the natural Upper Skagit summer chinook salmon population that can be mass marked and monitored through the coast-wide coded wire tag recovery database to estimate harvest impacts on the natural population. This program may lead to a moderate increase (800 to 1,000 adults) in the total abundance of Upper Skagit summer chinook adults, given the 200,000 annual subyearling release level, assuming a smolt survival to adult return of 0.5 percent, and taking into account the annual 150 adult broodstock removal need. NMFS (2003) estimated that 2 percent (~190 fish) of the 1998-2002 geometric mean total naturally spawning population of 9,489 fish were of hatchery origin, potentially from this program. The progeny of spawners collected from the run at large in the Upper Skagit River are released as subyearlings from an acclimation pond near Newhalem, adjacent to the major spawning area for the donor summer chinook population. Hatchery adults escaping to the Skagit River watershed would therefore be expected to spawn with natural summer chinook salmon in the upper river, rather than returning to Marblemount Hatchery.

Best management practices are applied in implementing the program, consistent with measures described for integrated programs in Appendix I. Specific measures implemented to minimize adverse genetic, ecological, and demographic effects on listed fish, including those under propagation at the hatchery, are included in the Marblemount Hatchery summer chinook HGMP, which describes hatchery fish production, monitoring and evaluation, and research actions (WDFW 2003g). Sections 6-9 of the HGMP describes broodstock collection, mating, and juvenile fish rearing measures that will be applied to minimize the risk of within and among population diversity loss to the donor listed, and artificially propagated, summer chinook salmon population. Measures implemented to minimize ecological effects on listed natural populations are described in appropriate sections of the HGMP. All juvenile fish released through the program are marked with coded wire tags. Juvenile emigrant trapping is conducted to assess the productivity and migration behavior of the naturally spawning summer chinook populations, and the post-release emigration behavior and survival of hatchery chinook populations, in the Skagit River watershed (Seiler et al., 2000, 2001, 2002).

6.2.6.4 Program Performance. As noted above, adults originating from the program may have comprised a recent five year (19985-2002) average proportion of the total summer chinook adult return to the Upper Skagit River watershed of 2 percent (data from NMFS 2003). Subyearling smolt-to-adult survival rates in recent years have averaged approximately 0.05 percent (preliminary data from WDFW 2003g). Escapement abundance trends calculated based on

limited mark recovery data in natural spawning areas indicates that the productivity of natural Upper Skagit summer chinook populations is at the replacement level (preliminary data from PS TRT, April 2004). The program is planned to continue indefinitely. Water intake screens for Marblemount Hatchery and the associated acclimation pond comply with NMFS' criteria (WDFW 2003g; NMFS 1995, 1996).

6.2.6.5 VSP Effects. The program may increase the total number of natural summer chinook spawners in the Upper Skagit River by circumventing potentially limiting natural early life developmental stages, but it is designed to have a neutral effect on donor, reference Upper Skagit summer chinook population, rather than to enhance its abundance. The program is relatively new (1994 start-up) and of modest size (200,000 subyearlings) and its success in returning spawners is as yet unknown. NMFS (2003) reported a 1998-2002 geometric mean natural spawner escapement for the Upper Skagit River population of 9,489 fish. The mean number of natural-origin spawners for this period was estimated to be 9,281, with 2 percent or 190 fish of the mean total naturally spawning population estimated as being of hatchery origin. Adult fish produced through the program return to natural spawning areas for the source population, and not to Marblemount Hatchery. Broodstock (up to 150 adults each year) are collected from the run at large in the Upper Skagit River, and the progeny of spawners are released as subyearlings from an acclimation pond near Newhalem, adjacent to the major spawning area for the donor summer chinook population. It is therefore assumed that the program has a neutral effect on the spatial structure of the population. Best management practices are applied to maintain the diversity of the donor population during operation of the hatchery program (WDFW 2003g). The program's effects on population productivity are unknown. NMFS (2003) reported a short term λ for the Upper Skagit River population of 1.05. Long and short term population trend estimates for the naturally spawning population were 1.00 and 1.06 respectively (NMFS 2003).

6.2.7 Marblemount Hatchery Fall Chinook

6.2.7.1 Broodstock/Program History. This new program was initiated in 1998 for the purpose of creating a mass marked indicator stock for assessment of natural-origin Lower Skagit River fall chinook harvest impacts in Pacific Northwest fisheries (WDFW 2003h; SaSI 2003). Like the summer chinook indicator stock program at Marblemount Hatchery, the fall chinook program is modest in size (160 adult fish are collected from the mainstem river to produce 222,000 subyearlings), and given its research (and not harvest augmentation) intent, adverse effects on the donor natural fall chinook population are not likely to be substantial.

Natural-origin Lower Skagit fall chinook adults are collected from lower mainstem river (~river mile 56) natural spawning areas each year for use as broodstock, so the hatchery and natural populations are the same. Hatchery broodstock are directly derived from the native population, and the program is considered representative of, and integrated with, the natural Lower Skagit fall chinook population.

6.2.7.2 Similarity of Hatchery Origin to Natural Origin Fish. Hatchery broodstock is collected

each year randomly from the returning Lower Skagit fall chinook run in the mainstem river (WDFW 2003h), and there are no genetic differences between the hatchery and natural populations. Hatchery-origin and natural-origin fall chinook salmon in the watershed share identical life history characteristics for the majority of the natural chinook salmon life cycle, including: seaward emigration as subyearlings in the mainstem Skagit River (Seiler et al., 2000, 2001, 2002—hatchery-origin fish are released during May-June, when natural-origin fall chinook subyearling smolts are also emigrating seaward (WDFW 2003h; Seiler et al., 2002); early rearing in Skagit River delta freshwater and estuarine, and North Puget Sound nearshore marine areas; emigration northward as smolts through Washington and British Columbia marine waters; rearing for two to five years from smolt-to-adult size in Northeast Pacific marine waters; migration through British Columbia and Washington marine waters as maturing two to five year old adults in the summer and early fall months; and freshwater entry and spawning in the lower Skagit River mainstem in early September to late October (SaSI 2003; WDFW 2003h). On the other hand, the hatchery-origin fish are artificially spawned, and their progeny are incubated and reared for approximately five months in a hatchery under controlled conditions, rather than being deposited as eggs in gravel reaches and rearing to emigrating fry or subyearling smolt size in the natural environment. Monitoring and evaluation of the genetic and ecological effects of the program are ongoing (WDFW 2003h; and for e.g., Seiler et al., 2002), and data collected will be used to adjust the hatchery program to meet its fish production and research objectives (WDFW 2003h).

6.2.7.3 Program Design. The program is designed to create a fully integrated surrogate for the natural Lower Skagit fall chinook salmon population that can be mass marked and monitored through the coast-wide coded wire tag recovery database to estimate harvest impacts on the natural population. This program may lead to a moderate increase (800 to 1,000 adults) in the total abundance of Upper Skagit summer chinook adults, given the 222,000 annual subyearling release level, assuming a smolt survival to adult return of 0.5 percent, and taking into account the need to remove 160 adults for broodstock each year. The program is new (first four year old returns were in 2002) and the program's contribution to natural spawning abundance is unknown. NMFS (2003) estimated that 0.2 percent (~ 1 fish) of the 1998-2002 geometric mean total naturally spawning population of 2,527 fish were of hatchery origin, potentially from this program. The progeny of spawners collected from the run at large in the lower Skagit River mainstem are released as subyearlings from an acclimation pond located at river mile 1 on the Baker River, adjacent to the Skagit River mainstem spawning area where broodstock were collected. Hatchery-origin fall chinook adults escaping to the Skagit River watershed are likely to spawn with natural fall chinook salmon in the lower mainstem river, rather than returning to Marblemount Hatchery where early rearing occurred.

Best management practices are applied in implementing the program, consistent with the measures described for integrated programs in Appendix I. Specific measures implemented to minimize adverse genetic, ecological, and demographic effects on listed fish, including those under propagation at the hatchery, are included in the Marblemount Hatchery fall chinook HGMP, which describes hatchery fish production, monitoring and evaluation, and research

actions (WDFW 2003h). Sections 6-9 of the HGMP describes broodstock collection, mating, and juvenile fish rearing measures that will be applied to minimize the risk of within and among population diversity loss to the donor listed, and artificially propagated, summer chinook salmon population. Measures implemented to minimize ecological effects on listed natural populations are described in appropriate sections of the HGMP. All juvenile fish released through the program are marked with coded wire tags. Juvenile emigrant trapping is conducted to assess the productivity and migration behavior of the naturally spawning spring chinook populations, and the post-release emigration behavior and survival of hatchery chinook populations, in the Skagit River watershed (Seiler et al., 2000, 2001, 2002).

6.2.7.4 Program Performance. The program is new, and smolt-to-adult survival rates and escapement levels to natural spawning areas are unknown. Escapement abundance trends indicate that the productivity of the natural Lower Skagit summer chinook population is at or slightly below the replacement level (preliminary data from PS TRT, April 2004). The program is planned to continue indefinitely. Water intake screens at the Marblemount Hatchery and the associated Baker River trap acclimation pond comply with NMFS' criteria (WDFW 2003h; NMFS 1995, 1996).

6.2.7.5 VSP Effects. The program may increase the total number of natural fall chinook spawners in the Lower Skagit River by circumventing potentially limiting natural early life developmental stages. However, the program is designed to have a neutral effect on the reference, donor Lower Skagit population, rather than to enhance its abundance. The program is new (1998 start-up) and of modest size (222,000 subyearlings), and its success in terms of returning spawners is unknown. NMFS (2003) reported a 1998-2002 geometric mean natural spawner escapement for the Lower Skagit River fall population of 2,527 fish. The mean number of natural-origin fall chinook spawners for this period was estimated to be 2,519, with 0.2 percent (~ 1 fish) of the mean total naturally spawning population estimated as being of hatchery origin. Adult fish produced through the program return to natural spawning areas for the source population, and not to Marblemount Hatchery. Broodstock (up to 160 adults each year) are collected from the run at large in the lower Skagit River. Progeny are released as subyearlings from an acclimation pond at RM 1.0 on the Baker River, adjacent to the major spawning area for the donor fall chinook population. It is therefore assumed that the program has a neutral effect on the spatial structure of the population. Best management practices are applied to maintain the diversity of the donor population during operation of the hatchery program. The program's effects on population productivity are unknown. NMFS (2003) reported a short term λ for the Lower Skagit River fall chinook population of 1.05. Long and short term population trend estimates for the naturally spawning population were 0.99 and 1.06 respectively (NMFS 2003).

6.2.8 Harvey Creek Hatchery/Whitehorse Springs Hatchery

6.2.8.1 Broodstock/Program History. This integrated conservation program was initiated in 1980 for the purpose of preserving and increasing the abundance of the native summer chinook salmon population in the North Fork Stillaguamish River, which had declined to critically low

abundance levels (Stillaguamish 2003; WDFW 2003i; SaSI 2003). Broodstock collection and juvenile fish production practices have evolved since initiation of the program to improve the performance of the program and to reduce risks to fish under propagation and to natural-origin summer chinook in the watershed. To decrease pre-spawning mortality rates, the Stillaguamish Tribe now curtails collection of broodstock from the North Fork Stillaguamish River when water temperatures exceed 15 °C (Stillaguamish 2003). This adjustment is expected to adequately protect the natural-origin summer chinook. The Tribe is also investigating use of a fish wheel trap as a less stressful alternative to the use of gill nets for the collection of chinook salmon broodstock, further diminishing pre-spawning mortality.

Native summer chinook broodstock used to establish (and presently implement) the program were gill-netted in the mainstem North Fork Stillaguamish River throughout the duration of the natural adult return period. Adult fish collected in the river are transferred to Harvey Creek Hatchery for holding through maturity, spawning, and rearing of progeny (Stillaguamish 2003). The hatchery juveniles are transferred to WDFW's Whitehorse Springs Hatchery in the upper North Fork Stillaguamish River watershed for rearing and release as subyearling smolts at river mile 27.8 (WDFW 2003i). The objective of the program is to preserve and increase the abundance of the naturally spawning North Fork Stillaguamish chinook population through hatchery supplementation. The aggregate natural and hatchery origin summer chinook salmon adult run at large in the river is collected each year as broodstock. Fish produced in the program are derived directly from the native population, and the program is fully integrated with the extant natural population.

6.2.8.2 Similarity of Hatchery Origin to Natural Origin Fish. Broodstock used in the program were derived, and are annually collected from, the total summer chinook adult return to the North Fork Stillaguamish River. Genetic differences between the natural and hatchery populations are therefore unlikely, and the aggregate return comprises one distinct stock (SaSI 2003). The hatchery population is currently listed under the ESA with its founding North Fork Stillaguamish River natural population, and with other natural-origin populations in the ESU. Hatchery-origin and natural-origin spring chinook salmon share identical life history characteristics for the majority of the natural chinook salmon life cycle, including: seaward emigration in the Stillaguamish River basin (Griffith et al., 2003—hatchery-origin juveniles are released during May when natural-origin fry are emigrating seaward); early rearing in Port Susan and north Puget Sound nearshore marine areas; emigration northward into British Columbia and Southeast Alaskan marine waters; rearing for two to five years from smolt-to-adult size in Northeast Pacific marine waters; migration through British Columbia and Washington marine waters as maturing two to five year old adults in the spring and early summer months; and freshwater entry and spawning in the North Fork Stillaguamish River watershed in mid August through the end of October (SaSI 2003; WDFW 2003i). On the other hand, the hatchery-origin fish are artificially spawned, and their progeny are incubated and reared in a hatchery under controlled conditions rather than being deposited as eggs in gravel reaches and rearing to emigrating fry or smolt size in the natural environment. Monitoring and evaluation of the genetic and ecological effects of the program are ongoing (Stillaguamish 2003; WDFW 2003i; Griffith

et al., 2003), and data collected will be used to adjust the hatchery program to meet its fish production and conservation objectives (Stillaguamish 2003).

6.2.8.3 Program Design. The program is specifically designed to preserve and increase the abundance of the native North Fork Stillaguamish summer chinook population, increasing prospects for its recovery to a viable, self-sustaining level. The program has been successful in increasing the number of naturally spawning spring chinook salmon in the North Fork Stillaguamish River (Stillaguamish 2003; WDFW 2003i; SaSI 2003). Mass marking of hatchery summer chinook with coded wire tags has allowed for assessments of their contribution rate to the naturally spawning population. Adults originating from the program have comprised an increasing proportion of the total naturally spawning population, accounting for greater than 50 percent of total spawning in recent years (Stillaguamish 2003; SaSI 2003).

Best management practices are applied in implementing the program, consistent with measures described for integrated programs in Appendix I, and with conservation hatchery program practices proposed in Flagg and Nash (1999). Specific measures implemented to minimize adverse genetic, ecological, and demographic effects on listed fish, including those under propagation at the hatchery, are included in the Tribal and WDFW HGMPs, which describe hatchery fish production, monitoring and evaluation, and research actions (Stillaguamish 2003; WDFW 2003i). Sections 6, 7, 8, and 9 of the HGMPs describe broodstock selection, collection, mating, and juvenile fish rearing measures that will be applied to minimize the risk of within and among population diversity loss to the donor listed, and artificially propagated, spring chinook salmon population. Measures implemented to minimize ecological effects on listed natural populations are described in HGMP sections 7.7, 9.3, 9.16, 9.17, 9.27, 10.9, and 11.1. All juvenile fish released through the program are marked with coded wire tags. Juvenile emigrant trapping is conducted to assess the productivity of the naturally spawning natural and hatchery origin summer chinook populations in the Nooksack River watershed (Griffith et al., 2003).

6.2.8.4 Program Performance. Adult returns from the hatchery program comprised an average of 30 percent (range 7 percent to 60 percent) of the total summer chinook return to the North Fork Stillaguamish River basin from 1990 through 1999 (Stillaguamish 2004). For 1988 to 1995, the smolt-to-adult survival rate for subyearling fish released from the hatchery programs averaged 0.81 percent, and ranged from 0.09 percent to 1.7 percent (Stillaguamish 2004). Recruit per spawner rates calculated based on mark recovery data in natural spawning areas indicates that the natural population is replacing itself. Brood year 1992-1996 recruit per spawner rates averaged 2.34 and ranged from 0.78 to 4.99 (Stillaguamish 2004). The program is planned to continue for 8 to 12 additional years to rebuild the population to a level where four consecutive years of escapement of 700 natural summer chinook or more are observed. The program may be discontinued at that time, or transition to an integrated harvest program. If the natural escapement target is not met, the program may continue as a conservation program or a harvest augmentation program until such time as a viable, self-sustaining natural population is restored. A hatchery weir is not used to collect broodstock, and no blockages or hindrance to upstream migration of salmon are associated with the programs. Water intake screens for the hatcheries

comply with NMFS' criteria (Stillaguamish 2003; WDFW 2003i; NMFS 1995, 1996).

6.2.8.5 VSP Effects. This conservation-directed program provides a substantial benefit to the preservation of the North Fork Stillaguamish summer chinook salmon population, a unique population that will likely be important for recovery of the Puget Sound chinook salmon ESU to a viable level. The hatchery population is currently listed under the ESA with its founding North Fork Stillaguamish natural population, and with other natural-origin populations in the ESU. The program benefits the abundance, diversity, and spatial structure of the reference population. NMFS (2003) reported a 1998-2002 geometric mean natural spawner escapement for the North Fork Stillaguamish population of 1,154 fish. The mean number of natural-origin spawners for this period was estimated to be 671. The remainder of the mean total number of spawners, 483 fish or 42 percent of the total escapement in the river, are hatchery-origin summer chinook jointly produced by the two programs. Adult fish produced through the program return to the natural spawning areas used by the source population, not to either of the hatcheries. Broodstock (up to 150 adults each year) is collected from the run at large in the North Fork Stillaguamish River and progeny are released as subyearlings from Whitehorse Springs Hatchery at RM 27.8 on the North Fork Stillaguamish. The release site is adjacent to the upper reaches of the natural spawning area for the donor summer chinook population (SaSI 2003). Measures are applied through the programs to maintain the diversity of the propagated population. Broodstock are collected randomly over the breadth of the return, an effective breeding population size of 666 fish (1997-2001) has been maintained, and a factorial mating scheme is used during spawning. The practice of releasing juveniles from the program adjacent to natural spawning areas reduces the potential for adverse effects to population spatial structure. The program's effects on productivity are unknown, but the continuing poor numbers of natural-origin spawners suggests that productivity in natural habitat remains poor, and that the contributions of naturally spawning hatchery fish are not leading to improved productivity. NMFS (2003) reported a short term λ for the composite (hatchery and natural chinook) North Fork Stillaguamish population of 0.92. In developing this estimate, it was assumed that the reproductive success of naturally spawning hatchery fish was equivalent to that of natural fish. Long and short term population trend estimates calculated on all spawners were 1.01 and 1.06 respectively (NMFS 2003).

6.2.9 Wallace River Hatchery Summer Chinook

6.2.9.1 Broodstock/Program History. WDFW's Wallace River Hatchery has released Skykomish stock summer chinook salmon subyearlings and yearlings into the Wallace River since 1973. Recent adjustments to the program that are beneficial to natural chinook population viability include substantially reducing the number of yearlings released each year, mass marking of fish released from the hatchery, adopting broodstock collection protocols that exclude transplanted non-native fall chinook salmon, and accommodating a transition for the neighboring Tulalip Bay chinook salmon program to the use of native broodstock. Ecological effects of yearling releases, and straying of hatchery fish into natural spawning areas used by other components of the Skykomish population spawn remain concerns. Further reductions or termination of the yearling release portion of the program would reduce the risk of harm to Skykomish population abundance and diversity. Implementation of proposals to incorporate natural-origin Skykomish summer chinook as broodstock (subject to the status of natural-origin returns) would reduce genetic diversity reduction risks to the natural Skykomish population associated with hatchery fish straying and spawning in natural areas.

The hatchery summer chinook population propagated through the program was originally established using adult summer chinook that returned to the fish passage facility at Sunset Falls on the Skykomish River. Since that time, the only broodstock source has been adult fish that returned to the Wallace River Hatchery traps (WDFW 2003j). Transplanted Green River hatchery lineage fall chinook were also propagated at the hatchery until 1996, when the fall chinook program was discontinued. The present summer chinook hatchery program uses only hatchery-origin adults as broodstock, but the program is intended to support an integrated harvest (WDFW 2003j). WDFW may propose to integrate natural origin Skykomish summer chinook in future years to meet this objective.

6.2.9.2 Similarity of Hatchery Origin to Natural Origin Fish. There has been no genetic sampling of the summer chinook population propagated through the program (fall chinook no longer produced at the hatchery were analyzed (Marshall et al., 1995). The program's broodstock collection history would indicate that summer chinook produced by the program are related to the natural Skykomish population. However, there has been little or no use of natural-origin fish in the hatchery broodstock, which may differentiate the hatchery population and should cause higher divergence from their Skykomish ancestry. The Wallace River Hatchery summer chinook population is considered part of the Puget Sound chinook salmon ESU.

Wallace River Hatchery-origin and Skykomish natural-origin summer chinook salmon share identical life history characteristics for the majority of the natural chinook salmon life cycle, including: seaward emigration in the Snohomish River basin (Nelson and Kelder 2002—hatchery-origin juveniles are released during the April-June period when natural-origin juveniles are emigrating seaward); early rearing in Everett Bay and north Puget Sound nearshore marine areas; emigration northward into British Columbia marine waters; rearing for two to five years from smolt-to-adult size in Northeast Pacific marine waters; migration through British

Columbia and Washington marine waters as maturing two to five year old adults in the summer months; and freshwater entry and spawning in the Skykomish River watershed in early June through September (SaSI 2003; WDFW 2003j). On the other hand, the hatchery-origin fish are artificially spawned, and their progeny are incubated and reared in a hatchery under controlled conditions for 5 months to one year rather than being deposited as eggs in gravel reaches and rearing to smolt size in the natural environment. Monitoring and evaluation of the genetic and ecological effects of the program are ongoing (Nelson and Kelder 2002; WDFW 2003j), and data collected will be used to adjust the hatchery program to meet its fish production and conservation objectives (WDFW 2003j).

6.2.9.3 Program Design. The program is designed to provide chinook salmon for commercial and recreational harvest. Past subyearling and yearling fall chinook releases have been 100 percent marked via otolith banding (Rawson et al., 2001). The Tulalip Tribes and WDFW have agreed to mass mark juvenile production at Wallace River Hatchery with an adipose fin clip and/or coded wire tags (WDFW 2003j). Best management practices are applied in implementing the program, as detailed in the Wallace River HGMP (WDFW 2003j). Hatchery practices are generally consistent with measures described for integrated programs in Appendix I, with the exception that natural summer chinook are not presently incorporated as broodstock in an effort to ensure that unmarked non-native fall chinook are not inadvertently incorporated as broodstock (WDFW 2003j).

6.2.9.4 Program Performance. The program is designed to be integrated with the natural summer chinook population in the Wallace River, but only hatchery origin fish are used as broodstock, and most adults produced by the program and escaping to the Skykomish River basin return to the hatchery weirs and traps and are removed at the hatchery. However, returning hatchery adults produced by the program also stray and spawn at substantial levels in the Skykomish River watershed (Rawson et al., 2001). NMFS (2003) estimated that a 1998-2002 average of 44 percent of the total Skykomish summer chinook escapement were hatchery-origin chinook, and data from Rawson et al. (2001) indicate that most of the hatchery fish are from Wallace River Hatchery. Juvenile fish released through the program are mass marked with adipose fin clips and/or coded wire tags, which will allow for stray rate assessments for this specific summer chinook program to be continued through the Snohomish Basin co-managers' planned spawning ground surveys (WDFW 2003j; 2003k). The program is proposed to be operated indefinitely to provide summer chinook adults for harvest. Smolt-to-adult survival rates for subyearlings (1995 brood year only) and yearlings (1997 brood year only) released through the program have been 0.1 percent and 0.7 percent respectively (WDFW 2003j; 2003k). A temporary weir used to collect summer chinook and coho salmon for use as broodstock from June through October blocks fish migration on the Wallace River at river mile 4. A hatchery weir on May Creek also blocks salmon migration. WDFW manually passes summer chinook (beginning in 2004, only unmarked [assumed natural] summer chinook will be passed) upstream of the Wallace River weir to seed natural spawning areas (WDFW 2003j). Water intake screens at the hatchery comply with NMFS' criteria (WDFW 2003j).

6.2.9.5 VSP Effects. The Wallace River Hatchery summer chinook program may have a neutral to slightly negative effect on VSP parameters for Skykomish summer chinook (the reference natural population for this program), and a neutral effect on other TRT delineated populations in the north Puget Sound sub-region. The program may enhance the abundance of the Wallace River component of the Skykomish population. NMFS (2003) reported a 1998-2002 geometric mean natural spawner escapement for the Skykomish population of 4,262 fish. The mean number of natural-origin Skykomish spawners for this period was estimated to be 2,392. The remainder of the mean number of natural spawners, 1,870 fish or 44 percent of the mean escapement in the river, are hatchery-origin summer chinook. Otolith mark recovery data indicate that the majority of these escaping hatchery fish originate from Wallace River Hatchery (Rawson et al., 2001). The 1997-2001 arithmetic mean total spawner escapement to Wallace River Hatchery is 2,040 adult fish (excludes jacks) (WDFW 2003j). The propagated population maintained by the hatchery is genetically similar to the founding natural-origin Wallace River aggregation, but the present use of only hatchery fish as broodstock and past transfers of out-of-basin fall chinook stock (now terminated) may have led to genetic divergence. Appropriate broodstock collection, spawning, and rearing protocols are applied through the program to maintain the diversity of the propagated population. Broodstock are collected randomly over the breadth of the return to the Wallace River and May Creek, a high effective breeding population size has been maintained ($N_e = 2,866$ for 1998-2001), and a factorial mating scheme is used during spawning. WDFW has proposed to incorporate natural-origin Skykomish summer chinook as broodstock at a 10 percent level to address genetic divergence concerns for the propagated population. Fish released through the program return predominately to the hatchery release site, and until recently, the hatchery weir prevent returning adult fish from accessing natural spawning areas in the upper Wallace River. Up to 500 natural-origin summer chinook are now passed above the weir each year to seed natural habitat (WDFW 2003j). With these recent fish passage protocols, the program is now viewed as having neutral effects on Skykomish population spatial structure. Effects of naturally spawning Wallace River Hatchery summer chinook on Skykomish population productivity are unknown. NMFS (2003) reported a short term λ for the composite (hatchery and natural chinook) Skykomish population of 0.87. In developing this estimate, it was assumed that the reproductive success of naturally spawning hatchery fish was equivalent to that of natural fish. The composite Skykomish naturally spawning population is not replacing itself on the short term, coincident with decades of high hatchery-origin contribution levels to natural spawning areas through straying. Long and short term population trend estimates calculated on all spawners were 0.99 and 1.07 respectively (NMFS 2003).

6.2.10 Tulalip Bay Hatchery Summer Chinook

6.2.10.1 Broodstock/Program History. The Tulalip Tribes' Tulalip Bay Hatchery has released Skykomish summer chinook salmon transferred as eggs from WDFW's Wallace River Hatchery since 1998. The Tulalip Bay hatchery program is supplied with summer chinook from Wallace River hatchery each year, and no adults are collected at the Tribal facility for spawning. Recent adjustments to the program that will likely benefit the viability of the natural Snohomish Basin chinook population include transitioning the main harvest augmentation program at the hatchery

location to the use of native Skykomish broodstock as a replacement for non-native Green River hatchery lineage stock. The above section describing the Wallace River Hatchery program broodstock and program history also applies to this program. The Tulalip Bay Hatchery summer chinook population is considered part of the Puget Sound chinook salmon ESU.

6.2.10.2 Similarity of Hatchery Origin to Natural Origin Fish. There has been no genetic sampling of the summer chinook population propagated through the Tulalip and Wallace River hatchery programs, but the Wallace River Hatchery broodstock collection history would indicate that summer chinook produced by the programs are related to the natural Skykomish population.

Tulalip Bay Hatchery-origin and Skykomish natural-origin summer chinook salmon share identical life history characteristics for the majority of the natural chinook salmon life cycle, including: early rearing in Port Susan, Everett Bay and north Puget Sound nearshore marine areas (Tulalip Bay Hatchery-origin juveniles are released directly into marine waters during the early to mid-May period when natural-origin Snohomish Basin chinook smolts are arriving and rearing in nearshore waters); emigration northward into Washington and British Columbia marine waters; rearing for two to five years from smolt-to-adult size in Northeast Pacific marine waters; and migration through British Columbia and Washington marine areas as maturing two to five year old adults in the summer months (Tulalip 2004a; WDFW 2003j); and freshwater entry and spawning in the Skykomish River watershed in early June through September (SaSI 2003; WDFW 2003j). On the other hand, a substantial majority of the hatchery-origin fish return to the Tulalip Bay release site (Tulalip 2003a) rather than to Snohomish Basin freshwater areas; the hatchery fish are artificially spawned from adults collected at Wallace River Hatchery, and their progeny are incubated and reared in a hatchery under controlled conditions for 5 months, rather than being deposited as eggs in gravel reaches and rearing to smolt size in the natural environment. Monitoring and evaluation of the genetic and ecological effects of the program are ongoing (Nelson and Kelder 2002; Tulalip 2004a), and data collected will be used to adjust the hatchery program to meet its fish production and conservation objectives (Tulalip 2004a).

6.2.10.3 Program Design. The program is designed to provide summer chinook salmon adults for commercial and recreational harvest in the Tribe's extreme terminal area fishing zone (Tulalip Bay). Subyearlings released through the program have been 100 percent marked via otolith banding (Rawson et al., 2001). Best management practices are applied in implementing the program, as detailed in the Tulalip Bay Hatchery summer chinook HGMP (Tulalip 2004a). Hatchery practices are generally consistent with measures described for integrated programs in Appendix I, with the exception that natural summer chinook are not presently incorporated as broodstock provided by Wallace River Hatchery as a measure to ensure that unmarked non-native fall chinook are not inadvertently incorporated as broodstock. (WDFW 2003j).

6.2.10.4 Program Performance. The program is designed to be integrated with the natural Skykomish summer chinook population, but only hatchery origin fish are used as broodstock, and most adults produced by the program return to Tulalip Bay, where they are captured and removed in high harvest rate fisheries (Tulalip 2004a; Rawson et al., 2001). A small proportion of the total annual hatchery adult return resulting from Tulalip Bay Hatchery chinook production strays and spawns in the Snoqualmie River watershed (Rawson et al., 2001). NMFS (2003) estimated that a 1998-2002 average of 44 percent of the total Skykomish chinook escapement, and 18 percent of the total Snoqualmie chinook escapement were hatchery-origin chinook. Data from Rawson et al. (2001) indicates that most of the hatchery fish in the Skykomish escapement are likely from Wallace River Hatchery and most in the Snoqualmie River basin were Tulalip Bay fall chinook salmon (a recently reduced program). Juvenile summer chinook released through the Tulalip Bay program are mass marked with thermally induced otolith bands, which will allow the Snohomish Basin co-managers to assess stray rates for this specific summer chinook program through planned spawning ground surveys (WDFW 2003j; 2003k). The program is proposed to be operated indefinitely to provide summer chinook adults for harvest. Recent year smolt-to-adult survival rates for subyearlings released through the program have been 0.1 percent (Tulalip 2004a). There is no native chinook salmon population in the watershed where the fish are released, and fish passage blockage and entrainment by the hatchery operation are not relevant risk factors for any natural chinook population.

6.2.10.5 VSP Effects. Hatchery summer chinook produced through this program are expected to have a neutral to slightly negative effect on VSP parameters for Snohomish Basin chinook, and a neutral effect on other TRT delineated populations in the north Sound sub-region. Although considered a within ESU, integrated program, the program is located out of the Snohomish River basin, and contributions to VSP parameters for the reference Skykomish population (if any) are inadvertent. With the Wallace River Hatchery program, stray fish that escape to the Skykomish River may enhance the abundance of one component of the Skykomish population that is genetically similar to its founding natural-origin Wallace River aggregation. Fish released through the program return predominately to the Tulalip Bay hatchery release site, where they are harvested in intensive Tribal fisheries (90 to 100 percent of the total annual hatchery adult returns are removed by this fishery (Tulalip 2004a)). No summer chinook broodstock are currently collected at Tulalip Bay Hatchery and the program relies on annual transfers of Wallace River hatchery for broodstock. Hatchery summer chinook escaping directed Tulalip Bay Tribal fisheries stray into the Snohomish River, in particular, into Snoqualmie River natural spawning areas (Rawson et al., 2001). Potential effects on the diversity of these natural populations may be the same as those surmised for straying Wallace Hatchery summer chinook. Skykomish population spatial structure is not likely enhanced by the Tulalip program. Effects on Skykomish population productivity attached with the Tulalip Bay Hatchery program are unknown. As noted above for the Wallace River Hatchery summer chinook programs, the natural chinook populations in the Snohomish Basin and reproducing at or below replacement levels, coincident with augmentation of naturally spawning chinook abundances with hatchery strays.

6.2.11 Tulalip Bay Hatchery Fall Chinook

6.2.11.1 Broodstock/Program History. This Tulalip Tribal program has released transplanted Green River hatchery-lineage fall chinook salmon juveniles into Tulalip Bay to augment the Tribal commercial fisheries since 1981. Recent adjustments to the program that are expected to benefit the viability of native Snohomish Basin chinook include: collecting late-arriving (fall-timed) summer chinook salmon at Wallace River Hatchery as broodstock for the program; reducing annual subyearling release levels of the fall chinook stock from 1.8 million to 200,000; and, transitioning the program from the primary harvest augmentation program at the hatchery to a harvest contribution assessment program.

The hatchery population propagated through the program originated from WDFW's Samish Hatchery, and from other WDFW hatcheries that propagate Green River lineage fall chinook, and is currently transplanted from WDFW's Samish Hatchery. The program presently relies on the collection of late migrating (post August 24) chinook salmon adults at Wallace River Hatchery for broodstock. No fall chinook adults are currently collected at the Tulalip Bay release site. The hatchery fall chinook stock used in the program is not native to the neighboring Snohomish watershed, and it is designed to be isolated from native chinook populations in that watershed. The transplanted, isolated hatchery population is not part of the Puget Sound chinook salmon ESU.

6.2.11.2 Similarity of Hatchery Origin to Natural Origin Fish. The hatchery population propagated through the program is considered to be substantially diverged from natural chinook populations in Puget Sound (SSHAG 2003) and out of the ESU. Genetic sampling of the fall chinook population propagated through the program (from collections at Samish Hatchery, Wallace River Hatchery, and other hatchery locations propagating Green River fall chinook) and the program's stock transfer history indicate that fish from the program are related to other transplanted Green River lineage hatchery populations, and distinct from the native Skykomish and Snoqualmie chinook populations (Marshall et al., 1995; SaSI 2003; PS TRT 2001). The propagated stock is not native to the Snohomish watershed, but the hatchery population does share many life history characteristics with natural fish from the point where the fish arrive as emigrating juveniles in marine waters, to the return of the fish as adults to marine waters in the vicinity of Tulalip Bay. Use of late-arriving adult fish escaping to Wallace River Hatchery as broodstock (that may be a mix between native summer chinook and transplanted feral Green River fall chinook) may make the genetic characteristics of the Tulalip Bay Hatchery fall chinook population more similar to the Skykomish population than the present hatchery stock. Monitoring and evaluation of the genetic and ecological effects of the program are ongoing (Nelson and Kelder 2002; Tulalip 2004b), and data collected will be used to adjust the hatchery program to meet its fish production and conservation objectives (Tulalip 2004b).

6.2.11.3 Program Design. The Tulalip Bay Hatchery program is designed to provide salmon for harvest in extreme terminal area Tribal fisheries at times and in an area isolated from natural chinook salmon populations. Juvenile fish populations released through the program have been

100 percent otolith marked (Tulalip 2004b; Rawson et al., 2001). Best management practices are applied in implementing the program, as detailed in the HGMP for the program (Tulalip 2004b). Hatchery practices are generally consistent with measures described for isolated programs in Appendix I.

6.2.11.4 Program Performance. The program is designed to be isolated from natural chinook populations, and most adults produced by the program return to Tulalip Bay, where they are captured and removed in high harvest rate fisheries (Tulalip 2004b; Rawson et al., 2001). A small proportion of the total annual hatchery adult return resulting from Tulalip Bay Hatchery chinook production strays and spawns in the Snoqualmie River watershed (Rawson et al., 2001). NMFS (2003) estimated that a 1998-2002 average of 44 percent of the total Skykomish chinook escapement, and 18 percent of the total Snoqualmie chinook escapement were hatchery-origin chinook salmon. Data from the 1997 and 1998 return years presented in Rawson et al. (2001) indicate that Tulalip Bay Hatchery chinook strays comprised 5 percent and 7 percent of the total Snohomish Basin chinook escapement in the two years, respectively. The recent reduction in the number of fall chinook juveniles released through the program, and the collection of late-migrating chinook at Wallace River hatchery as broodstock to sustain the program, are expected to reduce stray rate levels and genetic introgression risks to the native Snohomish Basin chinook populations. Estimated total Tulalip Bay Hatchery fall chinook smolt-to-adult survival rates for brood years 1986-1991 averaged 0.61 percent (range 0.28 percent to 1.22 percent), with total contributions of age two to five adults to fisheries averaging 1,323 fish (range 430 to 2,348 fish) (Tulalip 2004c). There is no native chinook salmon population in the watershed where the fish are released, and blockage and entrainment of fish by the hatchery operation are not risk factors for any natural chinook population.

6.2.11.5 VSP Effects. The program is expected to have a neutral to slightly negative effect on Snohomish Basin chinook, and other TRT delineated populations in the north Sound sub-region. The program has been reduced substantially, with transition from use of Green River-lineage fall chinook stock to Wallace Hatchery summer chinook as the primary harvest augmentation stock at Tulalip Bay Hatchery. Release through the program of Green River-lineage fall chinook subyearlings that are progeny of late-arriving broodstock collected at Wallace River hatchery continues for harvest contribution evaluation purposes (Tulalip 2004b). VSP parameters for natural-origin Green River or Snohomish Basin chinook do not benefit from this program, as the hatchery stock is substantially diverged from, and not representative of, any extant Puget Sound chinook population (SSHAG 2003). The hatchery population propagated through the program is designated as an out-of-ESU stock.

6.2.12 Tulalip Bay Hatchery Spring Chinook

6.2.12.1 Broodstock/Program History. This Tulalip Tribal program released transplanted Marblemount Hatchery spring chinook salmon yearlings into Tulalip Bay for Tribal ceremonial and subsistence fisheries purposes beginning in 1995. The program has been temporarily

suspended by the Tulalip Tribe (Tulalip 2004c), and no fish have been released through the program for two years.

The hatchery population propagated through the program originated from WDFW's Marblemount Hatchery. The program continued to rely on the collection of spring chinook salmon adults at the Cascade River facility through 2002, when the program was suspended. No spring chinook adults have been collected as broodstock at the Tulalip Bay release site. The hatchery spring chinook stock used in the program is not native to the neighboring Snohomish watershed, and it is designed to be isolated from native chinook populations in that watershed. The transplanted, isolated hatchery population is not part of the Puget Sound chinook salmon ESU (SSHAG 2003).

6.2.12.2 Similarity of Hatchery Origin to Natural Origin Fish. The hatchery population propagated through the program is considered to be substantially diverged from natural chinook populations in Puget Sound (SSHAG 2003) and out of the ESU. The propagated stock is not native to the Snohomish watershed, and spring chinook salmon are not an extant chinook race in the Basin.

6.2.12.3 Program Design. The Tulalip Bay Hatchery program is designed to provide spring salmon for harvest in extreme terminal area Tribal ceremonial and subsistence fisheries at times and in an area isolated from natural chinook salmon populations. Juvenile fish populations released through the program have been 100 percent otolith marked (Tulalip 2004c). Best management practices are applied in implementing the program, as detailed in the HGMP (Tulalip 2004c). Hatchery practices are generally consistent with measures described for isolated programs in Appendix I.

6.2.12.4 Program Performance. The program is designed to be isolated from natural chinook populations, and most adults produced by the program return to Tulalip Bay, where they are captured and removed in fisheries (Tulalip 2004c). Adult returns to the Tulalip Bay harvest area resulting from the modestly sized yearling release program have been low, and hatchery spring chinook stray rates to Snohomish basin natural chinook spawning areas are probably not substantial. Estimated total smolt-to-adult survival rates for brood years 1993-97 averaged 0.68 percent (range 0.27 percent to 1.54 percent), with total contributions of age two to five adults to fisheries averaging 244 fish (range 99 to 505 fish) (Tulalip 2004c). There is no native chinook salmon population in the watershed where the spring chinook yearlings have been propagated and released, and fish passage blockage and entrainment by the hatchery operation are not relevant risk factors for any natural chinook population.

6.2.12.5 VSP Effects. The program is expected to have a neutral to slightly negative effect on Snohomish Basin chinook, and other TRT delineated populations in the north Sound sub-region. The program, which releases out-of-basin origin Marblemount Hatchery spring chinook as yearlings, has been suspended by the Tulalip Tribe until further notice, pending assessment of its harvest benefits (Tulalip 2004c). VSP parameters for natural-origin Upper Cascade spring

chinook and Snohomish Basin chinook do not benefit from this program, as the hatchery stock is substantially diverged from, and not representative of, any extant Puget Sound chinook population (SSHAG 2003). The Marblemount Hatchery spring chinook population propagated and released as yearlings at the Tulalip Bay site is designated as an out-of-ESU stock.

6.2.13 Issaquah Hatchery Fall Chinook

6.2.13.1 Broodstock/Program History. WDFW's Issaquah Hatchery fall chinook program was founded in 1937 for the purpose of creating a chinook salmon run in the Sammamish watershed (WDF 1939). The program is presently operated primarily as a harvest augmentation program, but public education regarding salmon biology is also a major objective (WDFW 2003l).

The Issaquah Hatchery population was founded as an isolated hatchery program using Green River fall chinook broodstock transplanted from WDFW's Soos Creek Hatchery (WDFW 2003l). The program has been self-sustaining since 1992, when transfers of Green River hatchery lineage fall chinook from other regional hatcheries were prohibited under WDFW's Fish Transfer Policy (WDFW 2003l; WDFW 1992). The program is located in a creek where no native chinook population existed, and where habitat features needed to sustain a natural chinook population are absent, and not historically present. The population used as broodstock is sustained primarily by juvenile hatchery releases, but recent information indicates that natural fish that are the progeny of naturally spawning hatchery fish may also contribute adult fish to the spawning population (Berge et al., 2003). The program is geographically, ecologically, and genetically disconnected from the extant Green River natural and hatchery population(s) originally used to found the hatchery population. The transplanted, isolated hatchery population propagated through the program is likely to be substantially diverged from any natural chinook populations in the region, and is therefore not considered part of the Puget Sound chinook salmon ESU.

6.2.13.2 Similarity of Hatchery Origin to Natural Origin Fish. The Issaquah Hatchery stock is significantly different genetically from the founding out-of-basin origin Green River fall chinook stock (Young and Shaklee 2000; SaSI 2003). Average timing of adult return to Issaquah Creek (a heritable genetic trait) has moved earlier by two weeks over the last 34 years as a result of artificial propagation at the transplanted location (Mundy and Cramer 1999). The program is designed to isolate out-of-basin origin hatchery fish from the two native chinook populations in the Lake Washington Basin (WDFW 2003h). First generation hatchery fish have comprised the majority of annual spawning populations at the hatchery for many generations and no Green River Basin natural chinook have been spawned, which differentiates the hatchery population and should cause higher divergence from their Green River ancestry (A. Marshall, WDFW, pers. comm., April 2004). Although occurring at low levels relative to total returns to the hatchery (Vander Haegen and Doty 1995), straying by Issaquah Hatchery fall chinook adults into the Cedar River and the North Lake Washington tributaries may pose genetic introgression risks to those indigenous natural-origin populations. In particular, adult fish straying into North Lake

Washington tributaries may have adversely affected the genetic diversity of any remaining native fish population, which is likely a composite hatchery/natural population now (SaSI 2003).

Issaquah Hatchery-origin and Lake Washington natural-origin summer chinook salmon share identical life history characteristics for the majority of the natural chinook salmon life cycle, including: seaward emigration in the Lake Washington basin (Seiler, 2001); early rearing in central Puget Sound nearshore marine areas; emigration northward into Washington and British Columbia marine waters; rearing for two to five years from smolt-to-adult size in Northeast Pacific marine waters; migration through British Columbia and Washington marine waters as maturing two to five year old adults in the summer months; and freshwater entry and spawning in the Lake Washington watershed in August through October (SaSI 2003; WDFW 2003l). On the other hand, the hatchery-origin fish are artificially spawned, and their progeny are incubated and reared in a hatchery under controlled conditions for 5 months, rather than being deposited as eggs in gravel reaches and rearing to smolt size in North Lake Washington tributaries or the Cedar River. Monitoring and evaluation of the genetic and ecological effects of the program are ongoing (WDFW 2003l), and data collected will be used to adjust the hatchery program to meet its fish production and conservation objectives.

6.2.13.3 Program Design. The current program is designed to provide chinook salmon for recreational and commercial harvest, and to improve public understanding of salmon biology and habitat requirements. The predominant fisheries benefiting from the program occur in Puget Sound marine waters (WDFW 2003l). Subyearling fall chinook releases from the hatchery are 100 percent adipose fin clipped, and a portion of these also receive a coded wire tag prior to release (WDFW 2003l). Best management practices are applied in the implementation of the program to produce adult fish for harvest purposes, as detailed in the Issaquah Hatchery HGMP (WDFW 2003l). Hatchery practices are generally consistent with measures described for isolated programs in Appendix I.

6.2.13.4 Program Performance. The program intent is to isolate hatchery production from natural chinook populations. However, the hatchery program is located in an area that is not removed from natural chinook populations, and recent mark recovery data indicates that stray rates of hatchery fish from the program into natural chinook spawning areas in the Lake Sammamish Basin have been substantial (Berge et al., 2003). Recent smolt-to-adult survival rates for the program are not available (WDFW 2003l). The program is proposed to be operated indefinitely to provide fall chinook adults for harvest opportunity. A temporary weir used to collect summer chinook and coho salmon for use as broodstock from late August through mid-November blocks fish migration on Issaquah Creek at river mile 3. WDFW manually passes fall chinook and coho salmon adults upstream of the weir to seed natural spawning areas in Issaquah Creek (WDFW 2003l). Water intake screens at the hatchery comply with NMFS' criteria (WDFW 2003l).

6.2.13.5 VSP Effects. The program may have a negative effect on VSP parameters for native Lake Washington Basin populations, and a neutral effect on other TRT delineated populations

native to the mid Sound sub-region. The reference (propagated) population for the Issaquah Hatchery program is Green River, a stock transferred for propagation at the hatchery beginning in 1937 from Soos Creek Hatchery “to create a chinook run in the Sammamish watershed” (WDF 1939). The program has been entirely self-sustaining since 1992, when transfers of Green River-lineage fall chinook from other hatcheries were no longer allowed. Issaquah Hatchery fall chinook that successfully spawn naturally in Lake Washington tributaries may contribute to the ESU-wide abundance of natural origin fish similar to Green River stock chinook. Mark recovery sampling indicates that 22 percent of the chinook salmon adults that spawned naturally in the three miles of creek downstream of the Issaquah Hatchery weir in 2003 were natural-origin fish (Berge et al., 2003). These natural-origin fall chinook are likely the progeny of naturally spawning Issaquah Hatchery fall chinook produced upstream (fall chinook adults that are surplus to hatchery broodstock collection needs are passed upstream to spawn naturally) or downstream of the hatchery weir. It is probable that naturally spawning hatchery fish observed in tributaries used by the North Lake Washington population (Berge et al., 2003) are Issaquah Hatchery strays. Recent genetic analyses of chinook salmon collected in Bear and Cottage Lake Creeks indicated that there is little genetic difference between the Bear and Cottage Lake Creek populations and the Issaquah Hatchery population (SaSI 2003, citing Marshall 2000 and Young and Shaklee 2000). The 1997-2001 arithmetic mean total spawner escapement to Issaquah Hatchery is 4,403 adult fish (WDFW 2003l). The Issaquah Hatchery population may benefit total abundance of natural-origin Green River-like fall chinook salmon within the ESU, but not other VSP parameters for the Green River population. The transplanted Issaquah Hatchery population was found to be genetically unrepresentative of the original founding Green River lineage population in Young and Shaklee (2000). The population is localized through 67 years of propagation at the hatchery site to ecological conditions in Issaquah Creek and Lake Washington, and has been geographically isolated from the natural Green River population since its inception in 1937. No measures have been applied in the hatchery program to maintain the genetic or ecological characteristics of the original founding Soos Creek Hatchery population, or of that hatchery’s donor Green River population. The program maintains a high effective breeding population size, however (1998-2001 $N_e = 4,633$ - WDFW 2003l). Due to the hatchery’s location, any natural spawning by Issaquah Hatchery fall chinook occurs outside of the natural range of the Green River population, so the spatial structure of the Green River population does not benefit from the program. Fall chinook produced through the program do not contribute significantly to natural spawning in the Green River, and it is unlikely they benefit the productivity of the natural Green River population in the Green River.

6.2.14 Portage Bay Hatchery Fall Chinook

6.2.14.1 Broodstock/Program History. Portage Bay Hatchery has released transplanted Green River hatchery-lineage fall chinook salmon juveniles into the Lake Washington Ship Canal since 1949. The hatchery program is self-sustaining through the collection of adult returns to the hatchery.

The hatchery fall chinook stock used in the program is not native to the Lake Washington watershed, and the program is designed to be isolated from neighboring natural populations. The hatchery population has been subjected to substantial selection for specific physical and biological traits through the program, and straying of adult fish into neighboring Lake Washington watersheds where natural chinook populations spawn is a genetic risk factor. Any risk to the viability of natural chinook populations posed by the program could be reduced by a transitioning to an alternate broodstock that is genetically representative of native Lake Washington chinook populations. The Portage Bay Hatchery population is considered to be substantially diverged from natural chinook populations within the region (SSHAG 2003), and it is not part of the Puget Sound chinook salmon ESU.

6.2.14.2 Similarity of Hatchery Origin to Natural Origin Fish. The Portage Bay Hatchery population is considered to be substantially diverged from natural chinook populations within the region (SSHAG 2003) and is not part of the Puget Sound chinook salmon ESU. There has been no genetic sampling of the fall chinook population propagated through the program, but the program's stock transfer history and broodstock collection and spawning protocols applied at the hatchery suggest that the Portage Bay Hatchery population is most closely related to other transplanted Green River lineage hatchery populations, and is distinct from native Lake Washington Basin chinook populations and all other natural populations within the ESU (Marshall et al., 1995; SSHAG 2003).

6.2.14.3 Program Design. The Portage Bay Hatchery program operates as an isolated program primarily for education and research purposes, but also functions (inadvertently) to provide salmon for harvest in Northeast Pacific fisheries. Subyearlings released through the programs have been 100 percent adipose fin clipped and coded wire tagged prior to release. Best management practices are applied in implementing the program, as detailed in the HGMP for the program (UW 2003a). Hatchery practices are generally consistent with measures described for isolated programs in Appendix I, with the exception of selective broodstock collection and mating practices.

6.2.14.4 Program Performance. Although the program is designed to be isolated from natural chinook populations, returning adults produced by the program stray into Lake Washington watershed streams where natural chinook populations spawn, including the Cedar River (Berge et al., 2003; PFMC coded wire tag recovery data, 2003). Juvenile fish released through the program are mass marked with adipose fin clips and coded wire tags, which will allow for stray rate assessments for this specific fall chinook program to be monitored through co-manager and King County spawning ground surveys in the Lake Washington Basin (WDFW 2003l; Berge et al., 2003). Estimated total smolt-to-adult survival rates for brood years 1988-96 averaged 0.88 percent (range 0.29 percent to 1.6 percent), with total contributions of age two to five adults to fisheries and escapement averaging 1,485 fish (range 219 to 3,111 fish) (UW 2003a). There is no native salmon population (and no natural salmon freshwater habitat features) at the hatchery location where program fish are propagated and released, and fish passage blockage and entrainment by the hatchery operation are not relevant risk factors for any natural chinook

population.

6.2.14.5 VSP Effects. Fall chinook salmon produced by the Portage Bay Hatchery program may have a neutral to slightly negative effect on Lake Washington Basin, and other TRT delineated populations native to the mid Sound sub-region. The hatchery population is transplanted and non-local in origin, and is not likely to be genetically or ecologically representative of the original founding Green River lineage stock, nor of any other chinook salmon population in Puget Sound. The hatchery population has been purposely modified through selection in the hatchery (UW 2003a), and has become localized through 52 years of propagation at the hatchery site to ecological conditions in the Lake Washington watershed. VSP parameters for natural-origin Green River and Lake Washington fall chinook do not benefit from this program, as the hatchery stock is substantially diverged from, and not representative of, any extant Puget Sound chinook population (SSHAG 2003). The hatchery population propagated through the program is designated as an out-of-ESU stock.

6.2.15 Soos Creek Hatchery Fall Chinook

6.2.15.1 Broodstock/Program History. WDFW's Soos Creek Hatchery has released indigenous Green River fall chinook salmon subyearlings into Soos Creek, a tributary of the Green River at river mile 33, since 1901. Recent adjustments to the program that are beneficial to natural chinook population viability include mass marking of fish released from the hatchery and upstream passage, above the Soos Creek weir, of adult fall chinook salmon surplus to hatchery broodstock needs to seed natural spawning areas.

The Green River fall chinook population propagated through the program was established in Soos Creek, where spawning by the native population was previously insignificant, using adult fall chinook trapped with two weirs in the mainstem Green River (Becker 1967). Adult fall chinook returns to Soos Creek were increased to the point where the hatchery program became self-sustaining in 1924, and trapping in the mainstem river became unnecessary (Becker 1967). Since that time, the predominant hatchery broodstock source has been adult fish returning to the hatchery weir, located at river mile 0.8 in Soos Creek (WDFW 2003m). Juvenile fall chinook originating from on-station broodstock collections at the hatchery comprised 97 percent of total fish releases from the facility between 1952 and 1994 (Tynan 1999). The present program uses the aggregate hatchery and natural-origin (an average of 39 percent of total annual broodstock collections) adult return to Soos Creek as broodstock, and the program is considered integrated with the natural Green River population (WDFW 2003m).

6.2.15.2 Similarity of Hatchery Origin to Natural Origin Fish. Allozyme analysis has shown no significant difference between natural-origin Green River fall chinook (Newaukum Creek) and Soos Creek Hatchery chinook (SaSI 2003). There is a significant amount of genetic interchange between the Soos Creek Hatchery and Green River natural chinook populations that return to the hatchery rack and are spawned every year, and conversely, between stray hatchery adults and natural chinook that intermingle in Green River Basin natural spawning areas (SaSI 2003). The

hatchery program incorporates natural-origin adults at a rate of 39 percent into broodstock, and a high effective breeding population size is maintained at the hatchery ($N_e = 14,000$ - WDFW 2003m). Mark recovery analyses estimate that first generation hatchery-origin fall chinook comprise a recent year average of 88 percent of the naturally spawning population in the Green River watershed (data from NMFS 2003). The hatchery population is considered part of the Puget Sound chinook salmon ESU.

Soos Creek Hatchery and Green River natural-origin chinook salmon share identical life history characteristics for the majority of the natural chinook salmon life cycle, including: seaward emigration as subyearling smolts in the Green River during May and June (data from Seiler et al., 2002); early rearing in Elliot Bay and central Puget Sound nearshore marine areas; emigration into Washington and British Columbia pelagic marine areas; rearing for two to five years from smolt-to-adult size in Northeast Pacific marine waters; migration through British Columbia and Washington marine waters as maturing two to five year old adults in the summer months; and freshwater entry and spawning in the Green River watershed in September through early November (SaSI 2003; WDFW 2003m). On the other hand, the hatchery-origin fish are artificially spawned, and their progeny are incubated and reared in a hatchery under controlled conditions for approximately 5 months, rather than being deposited as eggs in gravel reaches and rearing to smolt size in the natural environment. In addition, juvenile out-migrant trapping has demonstrated that a substantial proportion of natural chinook salmon emigrate downstream in February and March as swim-up fry, with a smaller proportion emigrating in the spring months as subyearlings with liberated hatchery subyearlings (Seiler et al., 2002). Monitoring and evaluation of the genetic and ecological effects of the program are ongoing, and data collected will be used to adjust the hatchery program to meet its fish production and conservation objectives (WDFW 2003m).

6.2.15.3 Program Design. The program is designed to provide chinook salmon for commercial and recreational fisheries harvest. Subyearling fall chinook releases have been 100 percent marked with adipose fin clips, with a proportion also receiving coded wire tags (WDFW 2003m). Best management practices are applied in implementing the program, as detailed in the Soos Creek HGMP (WDFW 2003m). Hatchery practices are generally consistent with measures described for integrated programs in Appendix I, with the exception that the proportion of stray hatchery fish comprising the total naturally spawning Green River population in recent years (estimated average of 88 percent, NMFS 2003) greatly exceeds the proportion of natural-origin fall chinook incorporated as broodstock at the hatchery each year (estimated average 39 percent, WDFW 2003m).

6.2.15.4 Program Performance. Soos Creek Hatchery is defined as an integrated program. Hatchery fall chinook stray rate and broodstock origin data indicate that this objective is being inadvertently met by the program. Returning hatchery adults produced by the program stray and spawn at substantial levels in Soos Creek and the mainstem Green River (WDFW 2003m; SaSI 2003). NMFS (2003) estimated a 1998-2002 geometric mean natural spawner escapement for the Green River population of 8,884 fish. NMFS (2003) also estimated that 88 percent of the total

annual Green River fall chinook escapement to natural spawning areas over this period were hatchery-origin chinook salmon. WDFW estimates that a 1990 through 1997 annual return year average of 39.4 percent (range 26 percent to 45 percent) of the fall chinook collected for use as broodstock in Soos Creek are natural-origin fish (WDFW 2003m). Juvenile fish released through the program are mass marked with adipose fin clips and/or coded wire tags, which will continue to allow for hatchery fish stray rate and broodstock composition assessments to be continued through on-going WDFW hatchery and stock monitoring activities (WDFW 2003m).

The program is proposed to be operated indefinitely to provide fall chinook adults for harvest. Soos Creek Hatchery subyearling total smolt-to-adult survival rates (contribution to fisheries and escapement) have averaged 0.54 percent, ranging from 0.1 percent to 2.6 percent for brood years 1986 through 1995 (WDFW 2003m). For brood years 1986 through 1993, average annual Soos Creek Hatchery-origin fall chinook adult contributions were 16,474 fish to harvest, 5,210 fish to the Soos Creek Hatchery weir, and 1,779 fish to natural spawning areas in the watershed (WDFW 2003m). The 1997-2001 arithmetic mean total spawner escapement to the Soos Creek Hatchery weir (a run-of-the-river weir blocking Soos Creek at stream mile 0.8) is 9,938 adult fish (excludes jacks) (WDFW 2003m). The weir, also used to collect returning hatchery origin coho salmon, is operated from early September through November. WDFW manually passes fall chinook adults that are surplus to hatchery broodstock needs upstream of the weir to seed natural spawning areas (WDFW 2003m). The majority of adult fish arriving at the weir that are surplus to broodstock collection needs (3,500 adults per year) are passed upstream (1997-2001 average of 4,505 fish (B. Sanford, WDFW pers. comm. April, 2004) to spawn naturally in upper Soos Creek. Surplus fall chinook in some years have also been sold as carcasses to fish buyers. Water intake screens at the hatchery comply with NMFS' criteria (WDFW 2003m).

6.2.15.5 VSP Effects. The fall chinook salmon population produced at Soos Creek Hatchery may have a beneficial effect on most VSP parameters for the reference Green River population, and a neutral effect on VSP parameters for other TRT delineated populations in Puget Sound. The program likely benefits the abundance, diversity, and, to a moderate extent, the spatial structure of the Green River population. The program inadvertently increases the total abundance of natural spawners in the Green River mainstem and in Soos Creek, but, as a fisheries enhancement program, it is designed to have a neutral effect on the original donor Green River population, rather than to enhance it. NMFS (2003) reported a 1998-2002 geometric mean natural spawner escapement for the Green River population of 8,884 fish, of which a geometric mean of 1,099 were natural-origin Green River fall chinook. The remainder of the mean number of natural spawners, 7,785 fish or 88 percent of the mean escapement in the river, are first generation, hatchery-origin fall chinook.

Genetic differences between the propagated population maintained by Soos Creek Hatchery and natural-origin fall chinook salmon in the Green River watershed (sampled in Newaukum Creek) are not significant (Marshall et al. 1995). This is understandable, given the significant amount of genetic exchange between natural and hatchery-origin chinook that return to the hatchery weir and are spawned each year, and between stray hatchery adults and natural origin fish that

together spawn natural spawning in the watershed. Best management practices are applied through the program to maintain the diversity of the propagated population and limit the likelihood for its divergence from the extant natural population. Broodstock are collected randomly over the breadth of the return to Soos Creek, a high effective breeding population size has been maintained in the hatchery, natural-origin fish are incorporated at a high proportion, and a factorial mating scheme is used during spawning. Fish released through the program return predominately to Soos Creek and to mainstem Green River spawning areas in the vicinity of the river's confluence with Soos Creek, and adult fish are allowed to access upstream areas in Soos Creek for natural spawning. Green River population spatial structure may therefore be moderately enhanced by the program.

The program's effects on productivity are unknown, but the poor abundance status of the natural-origin population (as evidenced by recent mark recovery data showing that a large proportion of natural spawning in the river is comprised of first generation hatchery-origin fall chinook) indicates that the natural population's productivity in the extant natural environment is poor. Evaluations by Seiler et al., (2000) indicate deposited egg to emigrating juvenile survival rates for naturally spawning fall chinook in Soos Creek and the Green River upstream of Soos Creek of 3.8 percent and 7.3 percent respectively (Seiler et al., 2002). These spawner productivity levels are within the range of survival rates reported for other natural-origin chinook salmon populations in the Pacific Northwest region (Groot and Margolis 1991). However, NMFS (2003) reported a short term λ for the composite (hatchery and natural chinook) Green River population of 0.67, indicating that the naturally spawning population is not replacing itself on the short term. In developing this estimate, it was assumed that the reproductive success of naturally spawning hatchery fish was equivalent to that of natural fish. Long and short term population trend estimates calculated on all spawners were 1.02 and 1.05 respectively (NMFS 2003). What have likely been decades of straying of substantial numbers of Soos Creek Hatchery fall chinook into natural spawning areas in the watershed have not appeared to have led to improved productivity of the naturally spawning population. If habitat conditions in the Green River watershed and in the estuary are limiting to natural chinook productivity, the Soos Creek Hatchery program stands as an important means to artificially sustain the reference population until (or if) habitat limiting factors are remedied.

6.2.16 Icy Creek Hatchery Fall Chinook

6.2.16.1 Broodstock/Program History. WDFW's Icy Creek Hatchery releases indigenous Green River fall chinook salmon yearlings into Icy Creek, a tributary to the Green River at river mile 48.3, since 1983. Recent adjustments to the program that are beneficial to natural chinook population viability include mass marking of fish released from the hatchery, and initiating of an adult fish trapping program in Icy Creek as a measure to remove hatchery adults and limit straying. Potential reform measures could include releasing the yearlings lower in the watershed (e.g., from Soos Creek Hatchery) to reduce predation risks and potential genetic introgression risks to the natural Green River population. The broodstock history for the program is described above in the Soos Creek Hatchery section.

6.2.16.2 Similarity of Hatchery Origin to Natural Origin Fish. Broodstock for the Icy Creek Hatchery program are collected at Soos Creek Hatchery, and no adults returning to Icy Creek are used in spawning (WDFW 2003n). For brood years 1989 through 1995, an annual average of 221 adult fall chinook originating from the Icy Creek program returned to the Soos Creek Hatchery weir (from coded wire tag data, WDFW 2003n), with a proportion of the annual escapement incorporated as broodstock. For these same brood years, an estimated 2,160 adults escaped to natural spawning areas in the Green River watershed. Like the Soos Creek Hatchery program, there is likely to be genetic exchange between the hatchery and natural populations. Icy Creek Hatchery-origin adults do not comprise a significant proportion of the population spawned annually at Soos Creek Hatchery, and the genetic relationship between the Icy Creek Hatchery population and the natural population is described above in the Soos Creek hatchery section. The hatchery population is considered part of the Puget Sound chinook salmon ESU.

Icy Creek Hatchery and Green River natural-origin chinook salmon share identical life history characteristics for a portion of the natural chinook salmon life cycle, including: early rearing in Elliot Bay and central Puget Sound nearshore marine areas; emigration into Washington and British Columbia pelagic marine areas; rearing for one to four years from smolt-to-adult size in Northeast Pacific marine waters; migration through British Columbia and Washington marine waters as maturing two to five year old adults in the summer months; and freshwater entry and spawning in the Green River watershed in September through early November (SaSI 2003; WDFW 2003n). On the other hand, the hatchery-origin fish are artificially spawned, and their progeny are incubated and reared in a hatchery under controlled conditions for approximately one year, rather than being deposited as eggs in gravel reaches and rearing to fry or subyearling smolt size in the natural environment. Juvenile out-migrant trapping has shown that naturally spawned fall chinook salmon in the Green River do not have a yearling emigration life history trajectory (Seiler et al., 2002). Monitoring and evaluation of the genetic and ecological effects of the program are ongoing, and data collected will be used to adjust the hatchery program to meet its fish production and natural population conservation objectives (WDFW 2003n).

6.2.16.3 Program Design. The program is designed to provide chinook salmon for recreational and commercial fisheries harvest. Yearlings released through the program are 100 percent marked with adipose fin clips and a proportion also receive coded wire tags (WDFW 2003n). Best management practices are applied in implementing the program, as detailed in the Icy Creek HGMP (WDFW 2003n). Hatchery practices are generally consistent with measures described for integrated programs in Appendix I, with the exception that the proportion of stray hatchery fish comprising the total naturally spawning Green River population in recent years (estimated average of 88 percent, NMFS 2003) greatly exceeds the proportion of natural-origin fall chinook incorporated as broodstock at the hatchery each year (estimated average 39 percent, WDFW 2003n). Also, the yearling life stage released through the Icy Creek program is not consistent with the life history characteristics of the natural Green River fall chinook population. Yearlings produced by the program may carry enhanced domestication effects, and may pose increased

ecological risks to natural fish through predation relative to subyearling life stage hatchery releases.

6.2.16.4 Program Performance. Icy Creek Hatchery is defined as an integrated program. Hatchery fall chinook stray rate and broodstock origin data indicate that this objective is being inadvertently met by the program. The number of Icy Creek Hatchery origin adults escaping all fisheries and returning to either the Soos Creek Hatchery or the spawning grounds averaged 2,381 for brood years 1989 through 1995 (WDFW 2003n). For those brood years, an average of 221 adults per release year returned to Soos Creek Hatchery and an estimated 2,160 adults escaped to natural spawning areas. The program contributes substantially to the abundance of the naturally spawning Green River fall chinook population. An annual (1989 through 1997) average of 22.7 percent of the total number of natural spawners in the upper Green River mainstem were estimated to have originated from Icy Creek Hatchery (i.e., based on coded-wire tag data from WDFW (2003n), which noted that small sample sizes (<4 percent) in five of these years, and the limited area sampled (river mile 33.8 to 41.4), make this data less than reliable when applied to the entire river). Yearlings released through the program are mass marked with adipose fin clips, and a proportion also receive coded wire tags, which will allow WDFW to assess stray rates and broodstock composition through its on-going hatchery and stock monitoring activities (WDFW 2003n).

The program is proposed to be operated indefinitely to provide fall chinook adults for harvest. Icy Creek Hatchery yearling total smolt-to-adult survival rates (contribution to fisheries and escapement) have averaged 2.09 percent for brood years 1989 through 1995 (excluding 1991, WDFW 2003n). For the same brood years, the average annual Icy Creek Hatchery-origin fall chinook adult contribution to fisheries and escapement was 5,461 fish (WDFW 2003n). Screens associated with the Icy Creek Hatchery program comply with NMFS' criteria (WDFW 2003n).

6.2.16.5 VSP Effects. The fall chinook population produced at Icy Creek Hatchery may have a beneficial effect on most VSP parameters for the reference Green River chinook population, and a neutral effect on VSP parameters for other TRT delineated chinook populations in Puget Sound. The program likely benefits the abundance, and, to a moderate extent, the spatial structure of the Green River population. The hatchery program relies on broodstock collected at Soos Creek Hatchery. Icy Creek yearlings survive to return at a fairly high rate (1989-1995 brood year smolt-to-adult survival averaged 2.09 percent—WDFW 2003n). Yearlings are released from the hatchery relatively high in the Green River watershed (RM 48) and Icy Creek Hatchery adults are observed spawning both in the mainstem river near the release site and in upper river tributaries (Newaukum Creek). These watershed areas are historically used by the Green River natural population, and the program may therefore be viewed as contributing spawners as placeholders for natural population spatial structure. Due to the longer duration of hatchery intervention needed to produce yearling fish, Icy Creek Hatchery fall chinook are likely at higher risk of domestication relative to subyearling fish produced at Soos Creek Hatchery (Berejikian and Ford (draft) 2003). Scientific understanding of the bearing that yearling

production has on the fitness of these fish as adults for natural spawning is unclear (e.g., Reisenbichler and Rubin 1999; Ardren 2003). Although adult fish produced by the Icy Creek program are not purposely used to sustain the program (broodstock are collected from the run-at-large to Soos Creek), the benefits of the program to Green River natural population genetic diversity and productivity are questionable.

6.2.17 Keta Creek Hatchery Fall Chinook

6.2.17.1 Broodstock/Program History. The Muckleshoot Tribe's Keta Creek Hatchery releases indigenous Green River fall chinook salmon fingerlings into the upper Green River watershed, upstream to presently impassable barriers to adult fish migration beginning at river mile 61 (the City of Tacoma diversion, and Howard Hanson Dam). The program has operated since 1987. Proposed actions that may benefit the program and natural chinook population viability include plans to provide upstream passage for adult fall chinook produced through the program and arriving at Tacoma's diversion dam. The broodstock history for fall chinook released through the program is described above in the Soos Creek Hatchery section.

6.2.17.2 Similarity of Hatchery Origin to Natural Origin Fish. Broodstock for the Keta Creek Hatchery program are collected at Soos Creek Hatchery, and no adults returning to Keta Creek are used in spawning (Muckleshoot 2004a). The genetic relationship between the Keta Creek Hatchery population and the natural Green River population is described above in the Soos Creek Hatchery section. The hatchery population is considered part of the Puget Sound chinook salmon ESU.

Keta Creek Hatchery and Green River natural-origin chinook salmon share identical life history characteristics for the majority of the natural chinook salmon life cycle, including: rearing through seaward emigration in the Green River; early rearing in Elliot Bay and central Puget Sound nearshore marine areas; emigration into Washington and British Columbia pelagic marine areas; rearing for two to five years from smolt-to-adult size in Northeast Pacific marine waters; migration through British Columbia and Washington marine waters as maturing two to five year old adults in the summer months; and freshwater entry and spawning in the Green River watershed in September through early November (SaSI 2003). On the other hand, the hatchery-origin fish are artificially spawned, and their progeny are incubated and reared in a hatchery under controlled conditions for two to three months, rather than being deposited as eggs in gravel reaches and rearing to fry or subyearling smolt size in the natural environment. In addition, the hatchery-origin fish must survive passage at two dams, which leads to substantial mortality (Muckleshoot 2004a). Monitoring and evaluation of the genetic and ecological effects of the program are ongoing, and the data will be used to adjust the hatchery program to meet its fish production and natural population conservation objectives (Muckleshoot 2004a).

6.2.17.3 Program Design. The program is designed to provide chinook salmon for recreational and commercial harvest. Fingerlings released in brood years 1999-2002 were 100 percent marked with adipose fin clips (Muckleshoot 2004a). Best management practices applied in

implementing the program are generally consistent with measures described for integrated programs in Appendix I.

6.2.17.4 Program Performance. The Keta Creek Hatchery program is defined as an integrated program. Fish released through the program in recent years have been mass marked with adipose fin clips, which will allow hatchery fish stray rate and broodstock composition assessments to be continued through on-going hatchery and stock monitoring activities in the Green River watershed.

The program is proposed to be operated indefinitely to seed vacant natural production areas above two dams to produce emigrating smolts, which provide fall chinook adults for harvest in downstream fishing areas. Keta Creek Hatchery yearling total smolt-to-adult survival rates (contribution to fisheries and escapement) have averaged 0.013 percent for brood years 1993 through 1995, and ranged from 0 percent to 0.03 percent (Muckleshoot 2004a). Assuming this survival rate (and factoring proportional coded wire tag recoveries by location), the program may contribute 54 adult fall chinook to marine fisheries and 21 fish to freshwater fisheries and escapement. Screens associated with the Keta Creek Hatchery program comply with NMFS' criteria (Muckleshoot 2004a).

6.2.17.5 VSP Effects. The Keta Creek Hatchery program relies on broodstock collected at Soos Creek Hatchery. As operated, the program is expected to have a neutral effect on all VSP parameters for the natural Green River fall chinook population. The program is modest in size, and adults produced by the program have not been able to return to spawn naturally in the upper river areas where the fish are released. Furthermore, studies have shown that the survival of fall chinook planted through the program to the mainstem river downstream of the dam and diversion on the river is poor (fish survival through Howard Hanson Dam is 1 percent to 14 percent (Muckleshoot 2004a)). The estimated annual escapement to the Green River is 21 adult fish produced through the program. Monitoring and evaluation of the effects of the program's up-river seeding strategy are underway, and plans to provide upstream passage to the few fall chinook adults produced by the program may increase its contribution to Green River population viability, in particular, population spatial structure.

6.2.18 Grovers Creek Hatchery Fall Chinook

6.2.18.1 Broodstock/Program History. The hatchery program was founded in 1978 using transplanted Green River hatchery-lineage broodstock from WDFW's Hoodsport Hatchery (1978), Soos Creek Hatchery (1979), and Tumwater Falls Hatchery (1980 and 1981 (Suquamish 2003; Dorn et al., 1996)). Only adult fall chinook returns to Grovers Creek Hatchery have been used to sustain the hatchery program in subsequent years. The program is located in an area where no self-sustaining, native chinook population existed (PS TRT 2003), and where habitat features needed to sustain a natural chinook population are absent and were not historically present. The hatchery population is sustained entirely by juvenile hatchery fish releases, and there is no production of natural-origin adults through natural spawning by hatchery fish at the

broodstock collection location (Grovers Creek) (Dorn et al., 1996). The program is geographically, ecologically, and genetically disconnected from the extant Green River natural and hatchery population(s) originally used to found the Grovers Creek Hatchery program. There has been no use of natural-origin fish in the hatchery broodstock, especially no Green River Basin wild chinook, which differentiates them, and should cause higher divergence, from their Green River ancestry (A. Marshall, WDFW, pers. comm., April 2004). No measures have ever been applied in the hatchery program to maintain the ecological and genetic characteristics of the Green River natural or hatchery populations, or of the transplanted hatchery-lineage populations from Hoodspout or Tumwater Falls hatcheries, used to found the Grovers Creek program.

6.2.18.2 Similarity of Hatchery Origin to Natural Origin Fish. The transplanted, isolated hatchery population propagated at Grovers Creek is likely to be substantially diverged from natural chinook salmon populations in the region, and is not considered to be part of the Puget Sound chinook salmon ESU. The East Kitsap region where the program is located does not have a native self-sustaining chinook salmon population (SaSI 2003; PS TRT 2003). Chinook returns to the area were introduced to, and are sustained by, Grovers Creek Hatchery production (Dorn et al., 1996). No genetic samples have been collected from the Grovers Creek Hatchery population to allow for its comparison with other Puget Sound chinook salmon populations. The program's stock transfer history indicates that the hatchery fish population is related to other transplanted Green River lineage hatchery populations, and distinct from other TRT-delineated chinook salmon populations in the ESU (Marshall et al., 1995; SaSI 2003).

6.2.18.3 Program Design. The program is designed to provide chinook salmon for Tribal commercial fisheries in the East Kitsap region in an area isolated from natural chinook salmon populations. The program also provides fish for harvest in Puget Sound marine area recreational fisheries. Subyearling and yearling fall chinook releases are now 100 percent adipose fin clipped prior to release (Suquamish 2003). Best management practices are applied in implementing the program to produce adult fish for an isolated harvest, as detailed in the Suquamish Tribe's HGMP (Suquamish 2003). Hatchery practices are generally consistent with measures described for isolated programs in Appendix I.

6.2.18.4 Program Performance. The intent of the program is to isolate hatchery production from natural chinook populations. The location of the hatchery program in an area well removed from natural chinook populations, and data indicating that past stray levels have been very low, suggest that the program is meeting its this objective (Vander Haegen and Doty 1995; Suquamish 2003). The estimated smolt-to-adult survival rates for Grovers Creek Hatchery fall chinook are 1.0 percent for fish released into Grovers Creek and 0.5 percent for fish released into hatchery satellite locations (e.g., Gorst Creek, Suquamish 2003). The 1981 through 1999 average annual number of adult fall chinook salmon escaping to Grovers Creek and collected for use as broodstock was 2,425 fish (Suquamish 2003). None of the adult fish returning to Grovers Creek spawn naturally due to the small, intertidal nature of the creek (Suquamish 2003; Dorn et al., 1996). Juvenile fish released through the program are now mass marked with adipose fin clips, and a proportion also receive coded wire tags, allowing for continued assessments of hatchery

fish contribution and stray rates into natural spawning areas (Suquamish 2003). The program is proposed to be operated indefinitely to provide fall chinook adults for harvest opportunity. There are no blockages or screens associated with the program that harm natural chinook salmon populations.

6.2.18.5 VSP Effects. The Grovers Creek Hatchery fall chinook program has a neutral effect on VSP parameters for natural TRT-delineated chinook salmon populations within the ESU. The reference Green River hatchery-lineage population used to found the hatchery stock is a transplanted species, which has been localized to a watershed in which no natural chinook salmon population was present historically (PS TRT 2003). The creeks planted through the program lack the habitat features necessary to sustain a naturally producing chinook salmon population (Suquamish 2003). If first generation Grovers Creek Hatchery-origin fall chinook successfully spawn in East Kitsap streams other than Grovers Creek (e.g., Gorst Creek), the program may potentially benefit total abundance of natural-origin Green River populations present within the ESU. However, juvenile out-migrant trapping in Gorst Creek in 2003 indicated that the adult hatchery fish that passed upstream to spawn naturally were almost completely unsuccessful in producing juvenile out-migrants, likely due to the high proportion of sand in the available spawning areas (P. Dorn, Suquamish Tribe, pers. comm., April, 2003). The Grover Creek Hatchery population has become localized through 26 years of propagation at the hatchery site to ecological conditions in the East Kitsap Peninsula, and has been geographically and genetically isolated from the natural Green River population and other Green River-lineage hatchery populations since the program became self-sustaining in 1982. No measures have been applied in the program to maintain the genetic or ecological characteristics of the original founding Green River-derived hatchery stock. It is unlikely that this hatchery population will benefit VSP parameters, other than (potentially) the ESU-wide abundance of the natural Green River population.

6.2.19 Voights Creek Hatchery Fall Chinook

6.2.19.1 Broodstock/Program History. WDFW's Voights Creek Hatchery has released transplanted Green River hatchery lineage fall chinook salmon subyearlings into Voights Creek, a tributary of the Carbon River in the Puyallup River watershed at river mile 33, since 1917 (WDFW 2003o). Recent adjustments to the program that benefit the viability of natural chinook populations include mass marking of fish released from the hatchery and upstream passage (above the Voights Creek Hatchery weir and the water intake structure) of adult fall chinook salmon that are surplus to hatchery broodstock needs in order to seed natural spawning areas. High numbers of Voights Creek Hatchery origin fall chinook adults stray into the White River, posing genetic introgression risks to the White River spring chinook salmon population (Puyallup Tribal fish passage data from 2003; Shaklee and Young 2003; WDFW 2003o). There is evidence that as many as 30 percent of the adult fish escaping to the Buckley trap are fall chinook and not spring chinook (Shaklee and Young 2003). Reform measures to address fall chinook straying into the White River could include a reduction in Voights Creek Hatchery juvenile release levels, and/or active removal of straying chinook adults with adipose fin clips at

the Buckley Trap to prevent them from commingling with White River spring chinook in natural spawning areas. Continued mass marking of Voights Creek Hatchery fall chinook will allow for their visual differentiation from natural-origin chinook for stock assessment, fish passage management (e.g., Buckley Diversion trap), and hatchery management purposes.

The hatchery fall chinook population propagated through the program was established in Voights Creek, where spawning by the natural Puyallup river chinook salmon population was apparently low (Puyallup Tribe and WDFW 2000). Small numbers of eggs from native fall chinook spawning in Voights Creek were initially procured on-station. Approximately 50,000 eggs were collected annually between 1918 and 1923, with production at Voights Creek augmented through fry transfers from Green River and lower Columbia region hatcheries to build up the run (WDFG 1926; 1928; 1930). A transplanted-origin fall chinook adult return of sufficient size to sustain the program was eventually established at Voights Creek Hatchery, with transfers of Green River hatchery lineage fish from other regional hatcheries made as needed to meet on-station fish production objectives (Puyallup Tribe and WDFW 2000). Transfers of Green River hatchery lineage fall chinook from other regional hatcheries comprised 24 percent of the total juvenile fish production at Voights Creek Hatchery from 1953 through 1992 (Tynan, 1999). The program has been self-sustaining since 1993 (WDFW 2003o; Puyallup Tribe and WDFW 2000). The present program uses the predominately hatchery-origin fall chinook that return to the hatchery as broodstock, and the program is considered integrated with the extant natural Puyallup River population (WDFW 2003m).

6.2.19.2 Similarity of Hatchery Origin to Natural Origin Fish. The transplanted Green River lineage hatchery stock produced by the program has likely supplanted any native fall chinook stock historically present in the watershed (WDFW 2003o; SaSI 2003; Puyallup Tribe and WDFW 2000). Allozyme analysis of naturally-spawning chinook in South Prairie Creek showed that they are most similar to Green River chinook and their hatchery derivatives, including Hood Canal, Puyallup, Deschutes, Skykomish and Issaquah hatchery chinook (Marshall et al. 1995; Puyallup Tribe and WDFW 2000). The localized hatchery stock is viewed as the best stock for re-establishing a self-sustaining fall chinook population in the watershed (WDFW and PSTT 2004). Actual proportions of natural fall chinook inadvertently incorporated as broodstock each year are unknown. However, the program likely incorporates few natural-origin adults as broodstock, as fall chinook are collected as voluntary returns to the hatchery (WDFW 2003o) and the rate of straying of natural fish into the hatchery pond is likely low. A high effective breeding population size is maintained through the program ($N_e = 4,440$ - WDFW 2003o), which should preserve the genetic diversity of the propagated population. The proportion of first generation hatchery-origin fall chinook comprising the total natural spawning escapement in the Puyallup River is unknown pending mark recovery evaluations. Hatchery fish spawning has been documented in all major tributaries to the river, and in the White River (WDFW 2003o). The hatchery population is considered part of the Puget Sound chinook salmon ESU.

Voights Creek Hatchery and Puyallup River natural-origin chinook salmon share identical life history characteristics for the majority of the natural chinook salmon life cycle, including:

seaward emigration as subyearling smolts in the Puyallup River Basin during May and June (unpublished data from the Puyallup Tribe, 2003); early rearing in Commencement Bay and central Puget Sound nearshore marine areas (Pacific International Engineering 1999); emigration into Washington and British Columbia pelagic marine areas; rearing for two to five years from smolt-to-adult size in Northeast Pacific marine waters; migration through British Columbia and Washington marine waters as maturing two to five year old adults in the summer months; and freshwater entry and spawning in the Puyallup River watershed in August through late October (SaSI 2003; WDFW 2003o). On the other hand, the hatchery-origin fish are artificially spawned, and their progeny are incubated and reared in a hatchery under controlled conditions for approximately 5 months, rather than being deposited as eggs in gravel reaches and rearing to emigrating fry or subyearling smolt size in the natural environment. In addition, juvenile out-migrant trapping has demonstrated that a substantial proportion of natural chinook salmon in the Puyallup River emigrate downstream in February and March as swim-up fry, with a smaller proportion emigrating in the spring months as subyearlings with liberated hatchery subyearlings (unpublished data from the Puyallup Tribe, 2003). Monitoring and evaluation of the genetic and ecological effects of the Voights Creek program are ongoing, and data collected will be used to adjust the hatchery program to meet its fish production and conservation objectives (WDFW 2003o; Puyallup Tribe and WDFW 2000; Shaklee and Young 2003).

6.2.19.3 Program Design. The program is designed to provide chinook salmon for commercial and recreational fisheries harvest. Beginning with 2000 brood year releases, Voights Creek hatchery subyearling fall chinook have been 100 percent marked with adipose fin clips, with a proportion also receiving coded wire tags (WDFW 2003o). Best management practices are applied in implementing the program, as detailed in the Voights Creek HGMP (WDFW 2003o). Hatchery practices are generally consistent with measures described for integrated programs in Appendix I.

6.2.19.4 Program Performance. Voights Creek Hatchery is defined as an integrated program. However, the proportion of natural fall chinook incorporated as broodstock at the hatchery each year is unknown and likely low. Stray rate data for hatchery fall chinook are currently being evaluated. The 2004 return year being the first when mass marked four year old hatchery-origin adults returned to the watershed, allowing for such evaluations. Preliminary information indicates that Voights Creek Hatchery fall chinook adults stray at substantial levels into the White River (Shaklee and Young 2003). NMFS (2003) estimated a 1998-2002 geometric mean natural spawner escapement for the Puyallup River population of 1,653 fish, with an unknown fraction being hatchery-origin fall chinook. Juvenile fish now released through the program are mass marked with adipose fin clips and/or coded wire tags, which will allow the comanagers to continue assessing the stray rates of hatchery fish and broodstock composition through on-going hatchery and stock monitoring activities (WDFW 2003o; Puyallup Tribe and WDFW 2000).

The program is proposed to be operated indefinitely to provide fall chinook adults for harvest. There is no recent data available indicating total smolt-to-adult survival rates for the program, because these fish have not been coded-wire tagged in the recent past. The 1997-2001 arithmetic

mean total fall chinook spawner escapement to Voights Creek Hatchery (fish returning to the hatchery ladder; no weir blocks upstream fish access) is 3,078 adult fish (excludes jacks) (WDFW 2003o). The hatchery requires 1,100 adult fall chinook each year to sustain the Voights Creek program, and the Puyallup Tribe's Diru Creek hatchery program. Up to 1,000 adult fish arriving at the hatchery that are surplus to broodstock collection needs have been trucked and released into the upper Puyallup River above Electron Dam to spawn naturally (WDFW 2003o; Puyallup 2003a). Before 1996, the hatchery weir in years blocked upstream salmon migration, but a run-of-the-river weir is no longer used to direct returning fall chinook into the hatchery and migrating fish can freely pass the hatchery. A ladder at the upstream water intake ½ mile above the hatchery allows adult fish access to natural spawning areas in Voights Creek. Water intake screens at the hatchery comply with NMFS' criteria (WDFW 2003o).

6.2.19.5 VSP Effects. The fall chinook population produced at Voights Creek Hatchery may have a beneficial effect on most VSP parameters for the reference Puyallup River natural population, and a potentially negative effect on VSP parameters for the other TRT delineated population in the watershed (White River). Monitoring and evaluation suggests that escaping hatchery-origin fish have been sustaining the abundance of the apparent naturally spawning population (SaSI 2003; Puyallup Tribe and WDFW 2000). The proportions of natural and hatchery origin fall chinook comprising natural escapement are unknown, but preliminary mark recovery data indicate widespread and substantial straying by hatchery fall chinook into natural spawning areas. Straying of the hatchery fish into natural spawning areas within the White River poses a risk to the genetic diversity of the White River population (Shaklee and Young 2003). Hatchery adults are being used to seed previously vacant natural spawning areas upstream of Electron Dam, benefiting naturally spawning fall chinook abundance in the watershed. Allozyme analyses indicate that the hatchery and natural fall populations are genetically the same. Best management practices are applied through the hatchery program to maintain the diversity of the propagated population. Broodstock are collected randomly over the breadth of the return to Voights Creek Hatchery, a high effective breeding population size has been maintained, and a factorial mating scheme is used during spawning (WDFW 2003o). The program is inadvertently benefiting the spatial structure of the population via straying of adult fish from the hatchery release site. Fish returning to Voights Creek Hatchery may freely bypass the hatchery weir and water intake to seed spawning areas in upper Voights Creek (WDFW 2003k). Surplus hatchery adults, and juvenile fish, have been provided to the Puyallup Tribe to seed natural production areas in the upper Puyallup River. The program's effects on productivity are unknown, but the poor abundance status of the Puyallup natural-origin population indicates that the natural population's productivity in the extant natural environment is poor, and that contributions by naturally spawning hatchery fish are not leading to improved natural fish productivity. NMFS (2003) reported a short term λ for the composite (hatchery and natural chinook) Puyallup population of 0.95. In developing this estimate, it was assumed that the reproductive success of naturally spawning hatchery fish was equivalent to that of natural fish. Long and short term population trend estimates calculated on all spawners were 1.02 and 0.96 respectively (NMFS 2003). If habitat conditions in the Puyallup River watershed and in the estuary are limiting to natural chinook productivity, the Voights Creek Hatchery program stands as an important means

to artificially sustain the Puyallup population until habitat limiting factors are remedied.

6.2.20 Diru Creek Hatchery Fall Chinook

6.2.20.1 Broodstock/Program History. The Puyallup Tribe's Diru Creek Hatchery releases fall chinook salmon subyearlings into Diru Creek, a lower Puyallup River tributary, and into the upper Puyallup River watershed from three acclimation ponds upstream of Electron Dam. Adult fall chinook trucked from Voights Creek Hatchery are also released into the upper Puyallup River mainstem as part of this program. The Diru Creek Hatchery program has been in operation since 1979, with acclimation pond releases in the upper river commencing in 1998 (Puyallup 2003a). Recent adjustments to the program that may be beneficial to natural chinook population viability include mass marking of fish released through the hatchery programs, and plans to create a localized fall chinook population for use in the program by collecting returning adults in Clark Creek rather than transferring broodstock from Voights Creek Hatchery. The on-station release program is modest in size (200, 000 subyearlings per year) relative to the Voights Creek hatchery program (1.6 million subyearlings per year). Straying risks posed by hatchery fall chinook to the White River chinook population are mainly associated with the Voights Creek program. Continued mass marking of Diru Creek Hatchery fall chinook will allow for their visual differentiation from natural-origin chinook for stock assessment, fish passage management (e.g., Buckley Diversion trap), and hatchery management purposes.

Hatchery fall chinook propagated through the program are the progeny of broodstock transferred from WDFW's Voights Creek Hatchery. The broodstock history for the Voights Creek hatchery fall chinook population is described above for that WDFW program. The Diru Creek Hatchery program is not presently self-sustaining, but may be in future years if the collection of returning adult fall chinook in Clark Creek is successful. The population propagated through the program is considered integrated with the extant natural Puyallup River population (Puyallup 2003a).

6.2.20.2 Similarity of Hatchery Origin to Natural Origin Fish. A description of the similarity of the hatchery fall chinook population propagated through the program with natural origin fish is described above for the Voights Creek Hatchery population. The Diru Creek Hatchery population is considered part of the Puget Sound chinook salmon ESU.

Diru Creek Hatchery and Puyallup River natural-origin chinook salmon share identical life history characteristics for the majority of the natural chinook salmon life cycle, including: seaward emigration as subyearling smolts in the upper and lower Puyallup River mainstem during May and June (unpublished data from the Puyallup Tribe, 2003); early rearing in Commencement Bay and central Puget Sound nearshore marine areas (Pacific International Engineering 1999); emigration into Washington and British Columbia pelagic marine areas; rearing for two to five years from smolt-to-adult size in Northeast Pacific marine waters; migration through British Columbia and Washington marine waters as maturing two to five year old adults in the summer months; and freshwater entry and spawning in the Puyallup River watershed in August through late October (SaSI 2003; WDFW 2003o). On the other hand, the

hatchery-origin fish are artificially spawned, and their progeny are incubated and reared in a hatchery under controlled conditions for approximately 5 months, rather than being deposited as eggs in gravel reaches and rearing to emigrating fry or subyearling smolt size in the natural environment. Again, juvenile out-migrant trapping has demonstrated that a substantial proportion of natural chinook salmon in the Puyallup River emigrate downstream in February and March as swim-up fry, with a smaller proportion emigrating in the spring months as subyearlings with liberated hatchery subyearlings (unpublished data from the Puyallup Tribe, 2003). Monitoring and evaluation of the genetic and ecological effects of the Diru Creek Hatchery program, including its associated acclimation ponds in the upper watershed, are ongoing (Puyallup 2003a; Puyallup Tribe and WDFW 2000; Shaklee and Young 2003), and data collected will be used to adjust the hatchery program to meet its adult fish production and upper Puyallup River fall chinook population restoration objectives.

6.2.20.3 Program Design. The program is designed to provide adult chinook salmon for harvest augmentation purposes, and to restore a self-sustaining naturally spawning fall chinook salmon population in the upper Puyallup River, upstream of Electron Dam. The dam was breached in 2001 with a fish ladder, allowing adult fish to access natural spawning areas blocked to migration since 1903. Beginning with 1999 brood year releases, Diru Creek Hatchery subyearling fall chinook have been 100 percent marked with adipose fin clips. Fall chinook released upstream of Electron Dam are mass marked with adipose fin clips and all fish also receive coded wire tags (Puyallup 2003a). Best management practices are applied in implementing the program to meet the harvest augmentation and fall chinook restoration objectives, as detailed in the Diru Creek HGMP (Puyallup 2003a). Hatchery practices are generally consistent with measures described for integrated programs in Appendix I, although the proportion of natural-origin fall chinook incorporated as broodstock at Voights Creek Hatchery is unknown.

6.2.20.4 Program Performance. Like Voights Creek Hatchery, Diru Creek Hatchery is defined as an integrated program. However, the proportion of natural fall chinook incorporated into the donor Voights Creek Hatchery broodstock each year is unknown and likely low, but hatchery fish stray rates to natural spawning areas in the basin appear to be substantial. However, the Diru Creek program actively fosters returns of Voights Creek Hatchery stock to natural spawning areas in the upper river as part of its restoration objective. Juvenile fish released through the program are mass marked with adipose fin clips and/or coded wire tags, which will allow for hatchery fish stray rate and broodstock composition assessments to be continued through ongoing co-manager hatchery and stock monitoring activities (Puyallup 2003a; Puyallup Tribe and WDFW 2000).

The program is proposed to be operated indefinitely to provide fall chinook adults for harvest. Releases of fall chinook juveniles and adults upstream of electron Dam will continue until a self-sustaining natural population is established in the upper river. Estimated smolt-to-adult survival rates for fish released into Diru Creek through the program for years which data are available (brood years 1984-86) ranged from 0.01 percent to 0.21 percent (Puyallup 2003a). Adult returns

to Clark Creek, where Diru Creek hatchery fall chinook adults are believed to spawn, have ranged up to 1,000 fish (1984 return year), but have generally numbered 200 to 300 fish in recent years (data from Puyallup 2003a). Juvenile hatchery fish survival rate and adult return estimates for upper Puyallup river juvenile hatchery fall chinook releases are not yet available. There are no structures associated with the program that block or hinder migration for any natural chinook salmon populations. Water intake screens at Diru Creek Hatchery and the three acclimation ponds operated in the upper watershed comply with NMFS' criteria.

6.2.20.5 VSP Effects. Diru Creek Hatchery relies on broodstock collected at Voights Creek Hatchery, and the information presented above for the Voights program regarding effects on VSP parameters also applies to this program. The program is expected to have neutral or slightly positive effects on VSP parameters for the reference natural Puyallup fall chinook population. The program is modest in size, and its benefits to the abundance of the naturally spawning Puyallup population are unknown, but likely low. Emigrating smolts produced through acclimation pond releases are subject to substantial mortality from the water diversion that feeds Lizard Lake and its associated hydroelectric operation. These losses likely limit survival to adult returns for the Diru Creek program. Adult fall chinook salmon that are successfully produced by the program likely return to spawn naturally in the upper river areas where the fish are released. By re-establishing fall chinook returns to the now accessible natural habitat that was blocked to salmon by Electron Dam for nearly 100 years, the hatchery program benefits the spatial structure of the Puyallup population. Monitoring and evaluation of the program's benefits to Puyallup natural population abundance and spatial structure are underway. As noted above in the Voights Creek Hatchery evaluation section, if habitat conditions in the Puyallup River watershed and in the estuary are limiting to natural chinook productivity, the fall chinook hatchery programs in watershed likely provide an important means to artificially sustain the Puyallup population until (or if) habitat limiting factors are remedied.

6.2.21 White River Hatchery

6.2.21.1 Broodstock/Program History. The program was initiated in 1989 to assist in preserving and restoring the native spring chinook salmon population in the White River (Muckleshoot 2004b; Muckleshoot et al., 1996). Broodstock collection and juvenile fish production practices have been implemented since initiation of the program to benefit the restoration of a viable natural-origin spring chinook in the watershed (Muckleshoot 2004b; Muckleshoot et al., 1996). Reform measures planned for potential implementation include incorporating natural-origin, known White River spring chinook salmon into annual spawning for within population genetic diversity preservation purposes, and curtailing the yearling release component of the hatchery program as a measure to lesson the risks of domestication effect.

Broodstock used to establish the program was transferred from Hupp Springs Hatchery in Carr Inlet, south Puget Sound, where a reserve population had been established beginning in 1974 to prevent the White River population from going extinct (Appleby and Keown 1994; Muckleshoot et al., 1996; WDFW 2003p). The co-managers' *Recovery Plan for White River Spring Chinook*

Salmon (Muckleshoot et al., 1996) provides detailed information regarding the history of artificial propagation efforts directed at the preservation of the White River population. The objective of the White River Hatchery program was to create an adult spring chinook return to the hatchery as a means to re-establish the population in its native watershed. The spring chinook salmon adult return established at White River Hatchery is now collected for use as broodstock as volunteers to the hatchery weir and trap, and through the collection and transfer of hatchery spring chinook collected across the river at the Buckley diversion trap (Muckleshoot 2004b). Natural-origin fish are not incorporated during spawning, as a measure to prevent unintentional spawning of fall chinook salmon into the spring chinook population. As a conservation hatchery program propagating broodstock derived from the native population, the program is considered integrated with the extant natural spring chinook population.

6.2.21.2 Similarity of Hatchery Origin to Natural Origin Fish. Genetic analyses of natural origin and White River Hatchery-origin spring chinook indicate that there are no significant differences between the natural-origin and hatchery population, and that they are one distinct stock (Marshall et al., 1995; Shaklee and Young 2003; SaSI 2003). Available data indicate that the White River hatchery and natural-origin aggregations are a composite population, and integrated rather than isolated. In many years before the 1980s, spring-timed chinook spawners could not return to the White River downstream of the dams due to dewatering of the river through dam operations (B. Graeber, NOAA fisheries, pers. comm.). Apparent, naturally-produced spring-timed chinook returning to the White River throughout the 1976-1991 period of artificial production are assumed in Muckleshoot et al. (1996) to have resulted from sporadic fry and smolt releases from the hatchery programs. Since 1992, the population returning to the Buckley trap and transported upstream has received substantial infusions of surplus White River Hatchery and Hupp Springs Hatchery-origin fish through the White River Acclimation Pond program (Muckleshoot 2004b). The acclimation pond program was specifically implemented to help reestablish spring chinook returns to the upper river areas blocked by the dams. Preliminary mark recovery data for '99 BY returns of mass marked three year olds in 2002 indicates that fish acclimated at the pond are contributing to the adult spring chinook return trapped at Buckley and transported upstream for release (C. Baranski, WDFW, pers. comm.; Muckleshoot Tribe Buckley trap mark recovery data, March 4, 2003). There is no data indicating that natural-origin adult fish and resultant hatchery adults become isolated from each other after transport and release above Mud Mountain Dam through segregation in natural spawning areas. The hatchery population is currently listed as protected under the ESA with natural-origin populations in the ESU.

Hatchery-origin and natural-origin spring chinook salmon share identical life history characteristics for the majority of the natural chinook salmon life cycle, including: seaward emigration in the White River and Puyallup River basins as smolts in May and June (unpublished juvenile out-migrant trapping data from Puyallup Tribe); early rearing in Commencement Bay and south Puget Sound nearshore marine areas; emigration into Washington and British Columbia pelagic marine waters; rearing for two to five years from smolt-to-adult size in Northeast Pacific marine waters, including Puget Sound (Doty 1994; Muckleshoot et al., 1996); migration through British Columbia and Washington marine waters as

maturing two to five year old adults in the spring and early summer months; and freshwater entry and spawning in the White River watershed in May through mid-September (Muckleshoot et al., 1996; Muckleshoot 2004b; SaSI 2003). On the other hand, the hatchery-origin fish are artificially spawned, and their progeny are incubated and reared in a hatchery under controlled conditions for five months to one year rather than being deposited as eggs in gravel reaches and rearing to smolt size in the natural environment. Monitoring and evaluation of the genetic and ecological effects of the program are ongoing (Muckleshoot 2004b), and data collected will be used to adjust the hatchery program to meet its fish production and conservation objectives.

6.2.21.3 Program Design. The program is specifically designed to preserve the native White River spring chinook population, increasing prospects for its recovery to a viable, self-sustaining level. The program has been successful in increasing the number of naturally spawning spring chinook salmon in the White River (Muckleshoot 2004b; SaSI 2003). Mass marking of hatchery spring chinook with coded wire tags has allowed for assessments of the program's success in returning spawners to the White River, and smolt-to-adult survival rates. Adults originating directly from the program have comprised from 10 percent to 50 percent of the total spring chinook adult return to the river since 1993 (data from Muckleshoot 2004b).

Best management practices are applied in implementing the program, and most are consistent with measures described for integrated programs in Appendix I, and with conservation hatchery program practices proposed in Flagg and Nash (1999). The exception is that natural spring chinook are not presently incorporated as broodstock, as a measure to prevent inadvertent incorporation of fall chinook salmon during spawning. Specific measures implemented to minimize adverse genetic, ecological, and demographic effects on listed fish, including those under propagation at the hatchery, are included in the White River Hatchery HGMP, which describes hatchery fish production, monitoring and evaluation, and research actions (Muckleshoot 2004b). Sections 6, 7, 8, and 9 of the HGMP describe broodstock selection, collection, mating, and juvenile fish rearing measures that will be applied to minimize the risk of within and among population diversity loss to the donor listed population and artificially propagated, spring chinook salmon population (an effective breeding population size (N_e) of 2,600 (1998-2001) is maintained). Measures implemented to minimize ecological effects on listed natural populations are described in HGMP sections 7.7, 9.3, 9.16, 9.17, 9.27, 10.9, and 11.1. All juvenile fish released through the program are marked with coded wire tags. Juvenile emigrant trapping has been conducted to assess the productivity of the naturally spawning spring chinook population in the watershed, and to record natural and hatchery juvenile emigration behavior.

6.2.21.4 Program Performance. Adult returns from the program comprised an average of 42 percent of the total spring chinook return to the White River from 1997 through 2001 (data from Muckleshoot 2004b). For brood years 1989 to 1995, the smolt-to-adult survival rate for fish released from the hatchery averaged 0.16 percent (range from 0.05 percent to 0.18 percent), and 0.6 percent for yearlings (range 0.25 percent to 1.5 percent) (data from Muckleshoot 2004b). NMFS (2003) reported a 1998-2002 geometric mean natural spawner escapement for the White

River population of 844 fish. The mean number of natural-origin spawners within this total for this period is unknown due to a lack of a differentiating mark on all hatchery-origin White River chinook brood years produced to supplement the naturally spawning population for the base return years. Mass marking of fingerling spring chinook provided to the Puyallup Tribe's White River Acclimation Pond program (Puyallup 2003b) and released into the upper white River will allow for assessments of natural-origin spring chinook contribution and productivity. The 1997-2001 arithmetic mean total hatchery-origin spawner escapement to White River Hatchery is 652 adult fish (excludes jacks) (Muckleshoot 2004b). The program is planned to continue indefinitely, or until a natural self-sustaining population is established in the White River watershed, and habitat features necessary for the re-establishment of a viable, self-sustaining natural population are restored. The Buckley Diversion dam blocks upstream migration at the hatchery location, and is used to direct returning hatchery-origin spring chinook into the hatchery. Mud Mountain Dam is also an impassable barrier to fish migration a few miles upstream. A trap and haul program at the Buckley Diversion is operated by the Army Corps of Engineers to transport migrating untagged salmon spawners upstream of Mud Mountain Dam. Water intake screening for the hatchery is in compliance with NMFS screening criteria (Muckleshoot 2004b).

6.2.21.5 VSP Effects. The hatchery population is currently listed under the ESA with its founding Hupp Springs Hatchery population. This conservation-directed program provides a substantial benefit to VSP parameters for the White River spring chinook salmon population, a unique population that is important for recovery of the Puget Sound chinook salmon ESU to a viable level. The program likely benefits the abundance, diversity, and spatial structure of the White River population. The hatchery program has been used, with two other south Puget Sound programs, to prevent extirpation of the White River population, and to re-establish hatchery and natural-origin spring chinook adult returns to the White River. With the Hupp Springs program, the hatchery has provided a genetic reserve for the White River population. Adequate measures are applied to maintain the genetic integrity and diversity of the propagated population. Only known (coded wire tagged) White River Hatchery-origin spring chinook are used as broodstock in order to prevent inadvertent incorporation of stray chinook from other populations. Broodstock are collected randomly over the breadth of the return, a high effective breeding population size has been maintained, and a factorial mating scheme is used during spawning. The co-managers are planning to incorporate natural origin spawners as broodstock in future years to reduce the risk of divergence between the hatchery and natural populations. The program benefits population spatial structure by providing surplus fingerlings to the White River Acclimation Pond program, which returns spring chinook to historically used spawning areas upstream of Mud Mountain Dam. The program's effects on productivity are unknown. However, NMFS (2003) noted that the White River population had among the highest estimated short term population trend and population growth rate of the 22 extant Puget Sound chinook populations evaluated. NMFS (2003) reported a short term (1990-2002) median population growth rate (λ) for the composite (hatchery and natural chinook) White River population escaping to the upper White River of 1.16. In developing this estimate, it was assumed that the reproductive success of naturally spawning hatchery fish was equivalent to that of natural fish. Long and short term

population trend estimates calculated on all spawners were 1.05 and 1.14 respectively (NMFS 2003).

6.2.22 White River Acclimation Ponds

6.2.22.1 Broodstock/Program History. The program was initiated in 1992 to assist in restoring a natural White River spring chinook salmon in upper White river watershed areas historically used by the population (Puyallup 2003b). Juvenile fish production practices have been implemented since initiation of the program to benefit the restoration of a viable natural-origin spring chinook in the upper watershed (Puyallup 2003b; Muckleshoot et al., 1996). Recent measures implemented to improve the program include application of a mass mark on juvenile fish planted at the three acclimation pond sites to allow for the differentiation of acclimation pond origin fish from natural origin fish when they return as adults to the White River.

Juvenile fish used to establish the program, and to sustain it at the present time, are White River spring chinook fingerlings originating from Hupp Springs Hatchery and White River Hatchery. Adult spring chinook returning to these hatcheries are spawned to provide fish for the White River Acclimation Pond program. The above section describing the broodstock history for the White River Hatchery program applies for this program. Like the White River Hatchery program, this program is considered integrated with the extant natural spring chinook population.

6.2.22.2 Similarity of Hatchery Origin to Natural Origin Fish. The above section describing the genetic and life history similarities between the hatchery and natural origin spring chinook populations applies for this program. As a measure to maintain the integrity of the donor stock, the Hupp Springs and White River Hatchery programs have used only returning marked hatchery-origin adults as broodstock to ensure that other chinook stocks are not inadvertently incorporated. Although divergence from the naturally spawning aggregation may be theorized as an expected consequence of this practice, there are no genetic data indicating that the hatchery stocks have diverged from the extant (reference) natural-origin spawning aggregation: unmarked, apparently natural-origin spring-timed fish collected at the Buckley trap and transported above Mud Mountain Dam. Genetic stock identification analyses suggest that successful spring chinook spawners in the upper White River watershed have allele frequencies similar to White River spring chinook that had been perpetuated throughout the captive brood/hatchery program (Marshall et. Al., 1995; Anne Marshall, WDFW, pers. comm., March, 2003). WDFW also compared allozyme data collected from 1995, 1996 and 1997 return year spring chinook adults sampled in the upper White River with data collected from juveniles at the White River and Hupp Spring hatcheries. Samples from naturally spawning adult fish clustered with those from hatchery juveniles in an analysis of genetic distances between White River stock and the south Puget Sound fall chinook hatchery and wild populations (data from Anne Marshall, WDFW, pers. comm., March, 2003). Monitoring and evaluation of the genetic and ecological effects of the program are ongoing (Puyallup 2003b; Muckleshoot 2004b). In particular, mark recovery data collected at the Buckley Diversion trap will be used to determine the effects of the program in returning adult fish to the watershed, and in fostering re-establishment of a natural population

in the upper white River watershed.

6.2.22.3 Program Design. The program is specifically designed to re-establish a spring chinook salmon adult return in the upper White River, increasing prospects for the recovery of the population to a viable, self-sustaining level. Preliminary mark recovery data collected at the Buckley Diversion trap indicate that the program has been successful in increasing the number of adult fish returning to the White River, and potentially the number of naturally spawning spring chinook salmon in the White River (unpublished adult chinook sampling data from Puyallup Tribe, December, 2003). Mass marking of hatchery spring chinook released from the acclimation ponds with ventral fin clips beginning in 2000 allows for assessment of the program's success in returning spawners to the White River, and smolt-to-adult survival rates. Preliminary data indicate that adults originating directly from the program comprised 10 percent to 20 percent of the total untagged spring chinook adult return to the Buckley Diversion trap in 2003 (unpublished data from Puyallup Tribe, December 2003b).

Best management practices are applied in implementing the program, and most are consistent with measures described for integrated programs in Appendix I, and with conservation hatchery program practices proposed in Flagg and Nash (1999). The exception is that natural spring chinook are not presently incorporated as broodstock at either the Hupp Springs or White River donor hatcheries. Measures implemented to minimize adverse genetic, ecological, and demographic effects on listed chinook salmon, including those under propagation at the hatchery, are included in the White River Acclimation Pond HGMP (Puyallup 2003b). All juvenile fish released through the program are marked with ventral fin clips. Juvenile emigrant trapping has been conducted to assess the productivity of the naturally spawning spring chinook population in the watershed, and to record natural and hatchery juvenile emigration behavior (unpublished data from Chris Phinney, Puyallup Tribe, 2003).

6.2.22.4 Program Performance. The performance of the program in years prior to 2003, is unknown due to the lack of a differentiating mark on hatchery-origin fingerlings released into the upper White River prior to the 2000 brood year. Mass marking of fingerling spring chinook released through the White River Acclimation Pond program will allow for assessments of natural-origin spring chinook abundance and productivity beginning with the 2003 return year. The 1992-2001 mean return of adult fish that either originated directly from the hatchery program, are the adult progeny of hatchery-origin spring chinook released to spawn in the upper watershed in past years, or the progeny of natural-origin spring chinook is 724 fish (range 316 to 2002) (Muckleshoot 2004b). The program is planned to continue indefinitely, or until a natural self-sustaining population is established in the White River watershed, and habitat features necessary for the re-establishment of a viable, self-sustaining natural population are restored. This hatchery program does not block or hinder juvenile or adult salmon migration, and water intake screening for the acclimation ponds is in compliance with NMFS screening criteria.

6.2.22.5 VSP Effects. The White River Acclimation Pond program relies on broodstock collected at White River Hatchery and Hupp Springs Hatchery, and the three programs operate

together to meet the same stock preservation and restoration objectives. The information presented above effects of the White River Hatchery program on VSP parameters also apply to this program. The White River Acclimation Pond program benefits VSP parameters for the White River spring chinook salmon population. The program has been used, with the White River and Hupp Springs hatchery programs, to prevent extirpation of the White River population, and to re-establish natural-origin spring chinook adult returns to the upper White River, thereby increasing the abundance of naturally spawning fish, consistent with benefits afforded by other conservation hatchery programs as highlighted in Berejikian et al. (2004). The program is also likely benefiting the abundance of natural-origin spring chinook in the watershed through natural spawning by hatchery-origin fish, and the creation of progeny in upper river tributaries. The program benefits the diversity of the White River population by creating a reserve population in the upper White River. The White River Acclimation Pond program component of the combined conservation hatchery effort is benefiting population spatial structure by re-establishing adult spring chinook returns into the upper White River watershed upstream of Mud Mountain Dam. The reference population historically accessed this area prior to the construction of the Buckley Diversion in 1911 and Mud Mountain Dam in 1948, both of which are impassable barriers to salmon migration (Muckleshoot et al. 1996). The effects of the program on White River chinook productivity are unknown. Mass marking of fingerlings released into the acclimation ponds beginning in 2000 should improve the capability to assess the productivity of the natural-origin White River population in the upper watershed.

6.2.23 Hupp Springs Hatchery

6.2.23.1 Broodstock/Program History. The program was initiated in 1974 to create a reserve White River spring chinook salmon population outside of the White River watershed, where habitat blockage, loss, and degradation were leading to the extinction of the native population (Appleby and Keown 1994; WDFW 2003p; Muckleshoot et al., 1996). Broodstock collection and juvenile fish production practices have been implemented to benefit the preservation of the population at its transplanted location. Recent measures include fertilization of 10 percent of the eggs spawned at Hupp Springs with milt spawned from White River Hatchery fish. This measure may reduce genetic divergence of the Hupp Springs population from the hatchery spring chinook population now returning to the White River.

Broodstock used to establish the program were transferred from WDFW's Garrison Springs Hatchery (where fish from the White River were originally transferred for creation of a reserve population) and from the White River where the remnant spring chinook return was being trapped at the Buckley Diversion (Appleby and Keown 1994; WDFW 2003p; Muckleshoot et al., 1996). The co-managers' *Recovery Plan for White River Spring Chinook Salmon* (Muckleshoot et al., 1996) provides detailed information regarding the history of artificial propagation efforts directed at the preservation of the White River population, including a description of the Hupp Springs hatchery-based effort. The objective of the Hupp Springs Hatchery program was to create an adult spring chinook return to the transplanted location. Spring chinook salmon returning to Minter Creek, established through the program, are now collected for use as

broodstock (WDFW 2003p). Only chinook salmon identified by coded wire tags as Hupp Springs Hatchery spring chinook are spawned, as a measure to prevent incorporation of fall chinook salmon into the spring chinook population. As a conservation hatchery program that propagates broodstock from the native White River population, the program is considered integrated with that population.

6.2.23.2 Similarity of Hatchery Origin to Natural Origin Fish. Genetic analyses of natural origin and White River Hatchery-origin spring chinook indicate that there are no significant differences between the natural-origin and hatchery populations, and that they are one distinct stock (Marshall et al., 1995; Shaklee and Young 2003). The Hupp Springs Hatchery population is currently listed as protected under the ESA with natural-origin populations in the ESU. Hatchery-origin and natural-origin spring chinook salmon share identical life history characteristics for the majority of the natural chinook salmon life cycle, including: early rearing in south Puget Sound nearshore marine areas as arriving smolts; emigration into Washington and British Columbia pelagic marine waters; rearing for two to five years from smolt-to-adult size in Northeast Pacific marine waters, including Puget Sound (Doty 1994; Muckleshoot et al., 1996); and migration through British Columbia and Washington marine waters as maturing two to five year old adults in the spring and early summer months (WDFW 2003b; SaSI 2003). On the other hand, the hatchery-origin adult fish return to a watershed removed from the natural range for the population where they are artificially spawned. Also, the progeny of the hatchery fish are incubated and reared in a hatchery under controlled conditions for five months to one year rather than being deposited as eggs in gravel reaches and rearing to smolt size in the White River watershed. Monitoring and evaluation of the genetic and ecological effects of the program are ongoing, and data collected will be used to adjust the hatchery program to meet its fish production and conservation objectives (WDFW 2003p).

6.2.23.3 Program Design. The program is specifically designed to preserve, and supplement through juvenile fish transfers, the native White River spring chinook population, increasing prospects for its recovery in its native watershed to a viable, self-sustaining level. The program has been successful in increasing the total abundance of White River spring chinook, as adults returning to Hupp Springs Hatchery, and as juveniles transferred to the White River Acclimation Ponds (WDFW 2003p). Mass marking of hatchery spring chinook with coded wire tags has allowed for assessments of the program's success in producing adult fish for use in spawning, and evaluation of smolt-to-adult survival rates.

Best management practices are applied in implementing the program, and most are consistent with measures described for integrated programs in Appendix I, and with conservation hatchery program practices proposed in Flagg and Nash (1999). The exception is that only known, Hupp Springs Hatchery-origin spring chinook adults have been incorporated as broodstock, as a measure to prevent inadvertent incorporation of fall chinook salmon during spawning. Specific measures implemented to minimize adverse genetic, ecological, and demographic effects on listed fish, including those under propagation at the hatchery, are included in the Hupp Spring Hatchery HGMP (WDFW 2003p). Sections 6, 7, 8, and 9 of the HGMP describe broodstock

selection, collection, mating, and juvenile fish rearing measures that will be applied to minimize the risk of within and among population diversity loss to the donor listed population and artificially propagated, spring chinook salmon population (an effective breeding population size has been maintained ($N_e = 1,600$ for 1998-2001)). Measures implemented to minimize ecological effects on listed natural populations in the ESU, including the White River population under propagation, are described in HGMP sections 7.7, 9.3, 9.16, 9.17, 9.27, 10.9, and 11.1. All juvenile fish released through the program are marked with coded wire tags.

6.2.23.4 Program Performance. Hupp Springs Hatchery is defined as an integrated conservation program. For brood years 1988 to 1993, the smolt-to-adult survival rate for fish released from the hatchery averaged 0.26 percent for subyearlings (range from 0.10 percent to 0.18 percent), and 0.48 percent for yearlings (range 0.13 percent to 0.8 percent) (WDFW 2003p). The 1997-2001 arithmetic mean escapement of hatchery-origin White River spring chinook to Minter Creek (the hatchery location) is 424 adult fish (excludes jacks) (WDFW 2003l). The broodstock collection goal for the hatchery program is 540 adults. There is no natural origin chinook population in the watershed where the hatchery is located (PS TRT 2003). The program is planned to continue indefinitely, or until a natural self-sustaining population is established in the White River watershed, and habitat features necessary for the re-establishment of a viable, self-sustaining natural population in the White River are restored. The hatchery program does not block or hinder juvenile or adult salmon migration of any natural chinook salmon populations. Water intake screening for the hatchery is in compliance with NMFS screening criteria (WDFW 2003p).

6.2.23.5 VSP Effects. The spring chinook salmon population produced through this program provides a substantial benefit to VSP parameters for the White River spring chinook population. Operating since 1974, the Hupp Springs program has performed as an out-of-basin reserve for the White River population, sustaining population abundance and diversity while habitat factors threatening the population's survival in its home watershed are being addressed. The program likely benefits the total abundance, and diversity, of the population. The Hupp Springs Hatchery program serves as a genetic reserve for the White River population, and activities centering around the program were responsible for preventing the extinction of the genome in the mid-1970s (Muckleshoot et al., 1996). Specific measures are applied in the hatchery program to preserve the diversity of the propagated Hupp Springs White River population. Only known (coded wire tagged) Hupp Springs Hatchery-origin spring chinook are used as broodstock to prevent inadvertent incorporation of stray fall chinook from other Puget Sound populations. Broodstock are collected randomly over the breadth of the return, a high effective breeding population size has been maintained, and a factorial mating scheme is used during spawning. For the past two years, milt from hatchery-origin chinook salmon spawned at White River Hatchery has been used to fertilize 10 percent of the eggs spawned at Hupp Springs as a measure to limit the risk of genetic divergence of the Hupp Springs population from fish returning to the White River. Most of the spring chinook juveniles produced by the program are released on-station, outside of the natural range for the reference population. However, surplus fingerlings are produced for transfer to the White River Acclimation Pond program, which benefits White River

population spatial structure. The program's effects on White River population productivity are unknown.

6.2.24 Minter/Coulter Creek Fall Chinook Salmon

6.2.24.1 Broodstock/Program History. The hatchery fall chinook population propagated at Minter Creek Hatchery was founded and sustained through direct imports from WDFW's Soos Creek Hatchery, and through regular transfers of Green River lineage eggs from Samish and Tumwater Falls hatcheries, beginning in 1946 (Salo and Noble 1953; WDF 1957). Intra-basin hatchery transfers of Green River lineage fall chinook continued as needed to meet on-station production goals through 1992, when the program began relying on localized adult returns to the creek (WDFW 2003q). Only adult fall chinook returns to the Minter Creek Hatchery trap been used to sustain the hatchery program in subsequent years. The program is located in an area where no self-sustaining, native chinook population existed (Salo and Noble 1953; PS TRT 2003), and where habitat features needed to sustain a natural chinook population are absent, and not historically present. The hatchery population is sustained entirely by juvenile hatchery fish releases, and there is likely insignificant production of natural-origin adults through natural spawning by hatchery fish in the 0.1 mile of Minter Creek downstream of the hatchery. The program is geographically, ecologically, and genetically disconnected from the extant Green River natural and hatchery lineage populations originally used to found the program. There has been no use of natural-origin fish in the hatchery broodstock, especially no Green River Basin wild chinook, which differentiates them, and should cause higher divergence, from their Green River ancestry (A. Marshall, WDFW, pers. comm., April 2004). Average timing of adult return to freshwater (a heritable genetic trait) has moved earlier by 5 weeks relative to the entry timing of Green River fall chinook over the last 34 years (Mundy and Cramer 1999). No measures have ever been applied in the hatchery program to maintain the ecological and genetic characteristics of the Green River natural or hatchery populations, or of the transplanted hatchery-lineage populations from Hoodspout or Tumwater Falls hatcheries, used to found the Grovers Creek program.

6.2.24.2 Similarity of Hatchery Origin to Natural Origin Fish. The transplanted, isolated hatchery population propagated at Minter Creek is likely to be substantially diverged from natural chinook salmon populations in the region, and is not considered to be part of the Puget Sound chinook salmon ESU. The deep south Puget Sound inlet where the program is located does not have a native self-sustaining chinook salmon population (SaSI 2003; PS TRT 2003). Fall chinook returns to the Carr Inlet area were introduced to, and are sustained by, Minter Creek Hatchery production. No genetic samples have been collected from the Minter Creek Hatchery population to allow for its comparison with other Puget Sound chinook salmon populations. The program's stock transfer history indicates that the hatchery fish population is related to other transplanted Green River hatchery lineage populations, and distinct from other TRT-delineated chinook salmon populations in the ESU (Marshall et al., 1995; SaSI 2003).

6.2.24.3 Program Design. The program is designed to isolate out-of-basin origin hatchery fall

chinook salmon from native chinook populations in Puget Sound, providing adult chinook salmon for recreational and Tribal commercial fisheries harvests. Subyearling fall chinook releases each year are 100 percent adipose fin clipped prior to release (first year was 1998), and a proportion also receive a coded wire tag (WDFW 2003q). Best management practices are applied in the implementation of the program to produce adult fish for isolated harvest purposes, as detailed in the WDFW's HGMP for the program (e.g., an effective breeding population size (N_e) of 7,500 (1998-2001) has been maintained - WDFW 2003q). Hatchery practices are generally consistent with measures recommended by NOAA Fisheries.

6.2.24.4 Program Performance. The program intent is to isolate hatchery production from natural chinook populations. The location of the hatchery program in an area well removed from natural chinook population spawning areas, and hatchery protocols applied to foster a self-sustaining, localized hatchery population (WDFW 2003q), are consistent with the program's isolated intent. Estimated recent year smolt-to-adult survival rates for Minter Creek Hatchery fall chinook subyearlings are not available (WDFW 2003p). The 1995 through 2001 average annual number of adult fall chinook salmon escaping to Minter Creek Hatchery and collected for potential use as broodstock was 6,149 fish, and ranged from 574 to 11,184 fish (WDFW 2003q). Few of the adult fish returning to Minter Creek spawn naturally due to the small, intertidal nature of the creek and the short expanse of the creek available for spawning downstream of the hatchery weir that is not intertidal. Stray rates into other watersheds for adult fish produced by the program appear to be low, and approximately 2 percent of total annual adult returns to Minter Creek (Vander Haegen and Doty 1995). Juvenile fish released through the program are mass marked with adipose fin clips, and a proportion also receive coded wire tags, allowing for continued assessments of hatchery fish contribution and stray rates into natural spawning areas (WDFW 2003q). The program is proposed to be operated indefinitely to provide fall chinook adults for harvest opportunity. There are no blockages or screen associated with the program that harm natural chinook salmon populations.

6.2.24.5 VSP Effects. The program has a neutral effect on VSP parameters for TRT-delineated Puget Sound chinook salmon populations. This hatchery population is considered substantially diverged from any natural chinook salmon populations and is not included in the Puget Sound chinook salmon ESU. The reference Green River stock is a transplanted species/stock that has been localized to the Minter Creek watershed where no natural chinook salmon population was historically present (NMFS 2003). A satellite facility - Coulter Creek hatchery, located in Case Inlet - also released Green River hatchery-lineage stock, but the program was terminated in 1995. Minter Creek lacks the habitat features necessary to sustain a naturally producing chinook salmon population. Very few fall chinook produced by the hatchery spawn naturally due to the small, intertidal nature of Minter Creek. If first generation Minter Creek Hatchery-origin fall chinook successfully spawn naturally in the 0.5 miles of available natural habitat downstream of the hatchery weir in Minter Creek, the program may potentially benefit total abundance of natural-origin Green River stock present within the ESU. Adequate measures are applied to maintain the diversity of the propagated population. Broodstock are collected randomly over the breadth of the annual return to Minter Creek, a high effective breeding population size has been maintained, and a factorial mating scheme is used during spawning (WDFW 2003q). The population is localized through 58 years of artificial propagation at the hatchery site to ecological conditions in Carr Inlet in deep South Sound, and has been geographically and genetically isolated from the natural Green River population and other Green River lineage hatchery populations since the program became self-sustaining in 1992. No measures have been applied in the program to maintain the genetic or ecological characteristics of the original founding Green River-derived hatchery stock. It is unlikely that this hatchery population will benefit VSP parameters, other than (potentially) ESU-wide abundance, of the natural Green River population.

6.2.25 Garrison Springs/Chambers Creek Fall Chinook Salmon

6.2.25.1 Broodstock/Program History. The two hatchery programs are located in the same, small south Puget Sound watershed and rely on hatchery fall chinook salmon broodstock collected at the same location in Chambers Creek. The Garrison Springs program produces subyearling fish and the Chambers Creek program releases yearlings. The two programs were founded in 1976 and 1998 respectively, using broodstock that were an admixture of 12 different Green River hatchery lineage populations transferred from other WDFW hatcheries within the Puget Sound region (WDFW 2003r). The programs began using localized adult fall chinook returns to the Garrison Springs Hatchery trap in 1993, and only adult fall chinook returns to the trap have been used to sustain the hatchery programs in subsequent years. The programs are located in an area where no self-sustaining, native chinook population existed (PS TRT 2003), and where habitat features needed to sustain a natural chinook population are absent, and not historically present. The hatchery population is sustained entirely by juvenile hatchery fish releases, and there is no production of natural-origin adults through natural spawning by hatchery fish at the broodstock collection location (Chambers Creek). The program is geographically, ecologically, and genetically disconnected from the extant Green River natural and hatchery populations originally used to found the hatchery programs. There has been no use of natural-origin fish in the hatchery broodstock, especially no Green River Basin wild chinook, which

differentiates them, and should cause higher divergence, from their Green River ancestry (A. Marshall, WDFW, pers. comm., April 2004). No measures have ever been applied in the hatchery programs to maintain the ecological and genetic characteristics of the founding Green River natural or hatchery lineage populations.

6.2.25.2 Similarity of Hatchery Origin to Natural Origin Fish. The transplanted, isolated hatchery population propagated by these two hatchery programs is likely to be substantially diverged from natural chinook salmon populations in the region, and is not considered to be part of the Puget Sound chinook salmon ESU. The watershed where the program is located does not have a native self-sustaining chinook salmon population (SaSI 2003; PS TRT 2003). The available habitat is not typical, productive fall chinook habitat and would not likely support a self-sustaining, naturally spawning fall chinook population (WDFW 2003r). Chinook returns to the area were introduced to, and are sustained by, annual juvenile fish releases by the programs. No genetic samples have been collected from the hatchery fall chinook population to allow for its comparison with other Puget Sound chinook salmon populations. The program's stock transfer history indicates that the hatchery fish population is related to other transplanted Green River lineage hatchery populations, and distinct from other TRT-delineated chinook salmon populations in the ESU (Marshall et al., 1995; SaSI 2003).

6.2.25.3 Program Design. The program is designed to provide chinook salmon for Puget Sound marine area recreational fisheries and Tribal commercial fisheries in the isolated vicinity of the juvenile hatchery fish release sites. Subyearling and yearling fall chinook releases through the programs are 100 percent adipose fin clipped prior to release, with a proportion also receiving coded wire tags for stock and fisheries contribution assessment purposes (WDFW 2003r; 2003s). Best management practices are applied in the implementation of the programs to produce adult fish for harvest, as detailed in the HGMPs for the programs (e.g., the effective breeding population size (N_e) has been maintained at 2,424 (1998-2001) (WDFW 2003r; WDFW 2003s).

6.2.25.4 Program Performance. The programs are intended to produce juvenile fall chinook, and adult fish for harvest, in an area isolated from natural chinook populations. The location of the hatchery program in a watershed presently and historically lacking a natural chinook population, and hatchery protocols applied to foster a self-sustaining, localized hatchery population (WDFW 2003r, 2003s), are consistent with the programs' isolated intent. For brood years 1979-81, 1987, and 1989-91 the subyearling smolt-to-adult survival rate for fish released from Garrison Springs Hatchery averaged 0.52 percent (range from 0.04 percent to 1.2 percent) (WDFW 2003r). Survival rates for yearlings released from Chambers Creek Hatchery are not available (WDFW 2003s). The 1995 through 2001 average annual number of adult fall chinook salmon escaping to the Garrison Springs Hatchery trap and collected for potential use as broodstock was 1,276 fish, and ranged from 773 to 1,670 fish (WDFW 2003r). Very few to none of the adult fish returning to Chambers Creek spawn naturally due to the small, intertidal nature of the 0.1 miles of creek available for spawning, and the desire to limit passage of hatchery fish upstream into the watershed where the species is not native. Stray rates of adult fish to watersheds where native chinook populations exist have been very low and less than 0.5 percent

of total adult returns (Vander Haegen and Doty 1995). Juvenile fish released through the programs are mass marked with adipose fin clips, and a proportion also receive coded wire tags, allowing for assessments of hatchery fish contribution and stray rates. The programs are proposed to be operated indefinitely to provide fall chinook adults for harvest opportunity. There are no blockages or screens associated with the programs that harm natural chinook salmon populations.

6.2.25.5 VSP Effects. These programs may have a neutral effect on VSP parameters for TRT-delineated Puget Sound chinook salmon populations. The Green River hatchery lineage population propagated through the programs is a transplanted species/stock that has been localized to hatcheries in the Chambers Creek watershed where no natural chinook salmon population was historically present. If some of these first generation hatchery-origin fall chinook salmon successfully spawn naturally downstream of the hatchery weir in Chambers Creek, the program may potentially benefit total abundance of natural-origin fall chinook that are related to Soos Creek Hatchery fall chinook. Measures are applied to maintain the diversity of the propagated population. Broodstock are collected randomly over the breadth of the annual return to Chambers Creek, a high effective breeding population size has been maintained, and a factorial mating scheme is used during spawning. The population is localized through 28 years of propagation at the hatchery site to ecological conditions in deep South Sound, and has been geographically and genetically isolated from the natural Green River population and other Green River-lineage hatchery populations since the program became self-sustaining in 1992. No measures have been applied in the program to maintain the genetic or ecological characteristics of the original founding Green River-derived hatchery stock (seven different hatchery populations or combinations of populations were used by the program between 1980 and 1990 - WDFW 2003r). It is unlikely that this hatchery population will benefit VSP parameters, other than (potentially) ESU-wide abundance, of the fall chinook resembling the Green River population.

6.2.26 Clear Creek and Kalama Creek Hatchery Fall Chinook

6.2.26.1 Broodstock/Program History. The Clear Creek and Kalama Creek hatchery fall chinook programs operated by the Nisqually Tribe are located on lower Nisqually River tributaries at river miles 6 and 9, respectively. The two programs were founded through juvenile fall chinook releases beginning in brood years 1990 and 1979 respectively. Broodstock transferred from several WDFW hatcheries propagating Green River hatchery lineage fall chinook were used to found and sustain the hatchery population now maintained at the Tribal hatcheries. Recent adjustments to the program that are beneficial to assessments of the performance of the programs, and their contribution of adult fish to natural spawning in the Nisqually River, include mass marking of fish released from the hatcheries.

The hatchery fall chinook population propagated through the two programs was established in two tributaries where spawning by natural-origin fall chinook salmon is not significant due to the lower river location of the tributaries (most natural spawning occurs upstream of mainstem river

mile 15), the low amount of attraction water provided by the tributaries, and differences in water chemistry characteristics (tributaries are spring fed; the river is glacially influenced (Nisqually 2003a; 2003b). The hatchery population propagated by the program was founded through transfers of fall chinook salmon eggs from WDFW's Soos Creek, Voights Creek, Tumwater Falls, George Adams, and McAllister Creek hatcheries. Adult fall chinook returns to the facilities had become established to the point where the programs became self-sustaining beginning in brood year 1992, and no further out-of-watershed broodstock transfers have occurred (Nisqually 2003a; 2003b). The present programs use hatchery-origin fall chinook returns volunteering to the two facilities as broodstock. The two Nisqually Tribal hatcheries are described as isolated harvest programs in the HGMPs (Nisqually 2003a; 2003b).

6.2.26.2 Similarity of Hatchery Origin to Natural Origin Fish. The transplanted Green River lineage hatchery stock produced by the programs (combined with releases of Green River hatchery lineage chinook into the watershed over the last 60 years) may have supplanted any native fall chinook stock historically present in the watershed (SaSI 2003; PS TRT 2003). Allozyme sampling of naturally spawning fall chinook in Nisqually River tributaries in 1999-2001 showed allele frequencies similar to those observed for a few other south Sound hatchery and natural populations (SaSI 2003). Current genetic characteristics of the naturally spawning population could reflect native stock characteristics and/or extensive introgression south Puget Sound hatchery fish, including fall chinook produced by the Nisqually programs (SaSI 2003; PS TRT 2003). The localized hatchery stock is viewed as the best stock for re-establishing a self-sustaining fall chinook population in the watershed (Nisqually 2003a; 2003b; Nisqually 1999). Actual proportions of natural origin fall chinook inadvertently incorporated as broodstock each year are unknown due to the lack until recently of a differentiating mark on hatchery origin adult fish. The programs likely incorporate few natural-origin adults as broodstock, as fall chinook are collected as volunteers to the hatchery traps, and natural fish straying into the trapping locations is likely low, and under 5 percent of the total collections (Nisqually 2003a; 2003b). A high effective breeding population size is maintained through the combined programs ($N_e = 9,200$ (1996-99) Nisqually 2003a; 2003b). Broodstock collection and spawning protocols, and the low intervention (subyearling release) artificial propagation strategy applied through the programs (Berejikian and Ford 2003), should help preserve the genetic diversity of the propagated population. The proportion of first generation hatchery-origin fall chinook comprising the total natural spawning escapement in the Nisqually River is unknown and pending mark recovery evaluations. The hatchery populations is considered part of the Puget Sound chinook salmon ESU.

Hatchery and natural-origin chinook salmon in the Nisqually River share identical life history characteristics for the majority of the natural chinook salmon life cycle, including: seaward emigration as subyearling smolts in the Puyallup River Basin during May and June; early rearing in Nisqually Delta and deep south Puget Sound nearshore marine areas; emigration into Washington and British Columbia pelagic marine areas; rearing for two to five years from smolt-to-adult size in Northeast Pacific marine waters, including Puget Sound; migration through British Columbia and Washington marine waters as maturing two to five year old adults in the

summer months; and freshwater entry and spawning in the Nisqually River watershed in September through October (SaSI 2003). On the other hand, the hatchery-origin fish are artificially spawned, and their progeny are incubated and reared in a hatchery under controlled conditions for approximately 5 months, rather than being deposited as fertilized eggs in Nisqually mainstem and upper tributary gravel reaches, and rearing to emigrating fry or subyearling smolt size in the natural environment. Monitoring and evaluation of the genetic and ecological effects of the Nisqually fall chinook hatchery programs are ongoing, and data collected will be used to adjust the programs to meet their fish production (and potentially natural spawning population restoration (Nisqually 1999) objectives (Nisqually 2003a; 2003b).

6.2.26.3 Program Design. The programs are designed to provide fall chinook salmon for harvest in Northeast Pacific commercial and recreational fisheries. Beginning with 1999 brood year releases, Clear Creek and Kalama Creek hatchery subyearling fall chinook have been 100 percent marked with adipose fin clips, with a proportion of the fish produced at Clear Creek Hatchery also receiving coded wire tags as part of a Pacific Salmon Treaty indicator stock program (Nisqually 2003a; 2003b). Best management practices are applied in implementing the programs, as detailed in the two HGMPs, to reduce genetic, ecological and demographic risks to natural chinook salmon populations included in the ESU. Current hatchery practices are generally consistent with measures described for isolated programs in Appendix I.

6.2.26.4 Program Performance. The Clear Creek Hatchery and Kalama Creek Hatchery program are defined as isolated programs (Nisqually 2003a; 2003b). The proportion of natural fall chinook incorporated as broodstock at the hatchery each year is unknown, but likely low and consistent with the programs' isolated intent. However, hatchery fall chinook stray levels into natural spawning areas in the watershed are unknown and currently being evaluated. The 2003 return year was the first year when mass marked four year old hatchery-origin adults returned to the watershed, allowing for stray rate evaluations for the programs. Juvenile fish released through the program are mass marked with adipose fin clips and/or coded wire tags, which will continue to allow for hatchery fish stray rate and broodstock composition assessments to be evaluated through on-going hatchery and stock monitoring activities (Nisqually 2003a; 2003b).

The programs are proposed to be operated indefinitely to provide fall chinook adults for harvest. The Nisqually Tribe estimates that the two hatchery programs may contribute 13,000 to 17,000 fish to in-river fisheries and escapement when both programs are at full production and assuming smolt-to-adult survivals at goal levels (0.65 percent to 0.85 percent) (Nisqually 2003a, 2003b). For brood years 1990 to 1993, estimated subyearling total smolt-to-adult survival rates for fish released from Clear Creek Hatchery averaged 0.804 percent (range 0.14 percent to 1.98 percent), providing an annual average of 5,604 fall chinook for fisheries harvest and escapement (Nisqually 2003a). For brood years 1982 to 1993, the subyearling total smolt-to-adult survival rate for fish released from Kalama Creek Hatchery averaged 0.408 percent (range 0.04 percent to 1.43 percent), providing an annual average for those brood years of 3,095 fall chinook for fisheries harvest and escapement (Nisqually 2003b). The 1995-1999 arithmetic mean total fall chinook adult escapements to Clear Creek and Kalama Creek hatcheries were 4,062 fish and

1,268 fish respectively (excludes jacks) (Nisqually 2003a; 2003b; 2003c). The combined hatcheries require 2,300 adult fall chinook each year to meet egg take requirements. Surplus fall chinook at the hatcheries are used for ceremonial and subsistence purposes, donated to the general public or sold to fish buyers. NMFS (2003) reported a 1998-2002 geometric mean natural spawner escapement for the Nisqually River population of 1,195 fish. No adult fish are passed upstream to spawn naturally at the tributary hatchery locations. The Tribe estimates that the programs contributed a 1990-93 brood year average of 1,596 fish to natural spawning areas in the mainstem river and upper tributaries (Nisqually 2003a; 2003b). The productivity of the naturally spawning population in the Nisqually River is currently unknown, and pending evaluation. Habitat blockage, loss, and degradation in the watershed have adversely affected features in the watershed that once supported a viable self-sustaining chinook population (Nisqually 1999). The estimated 1988 through 1997 brood year mean number of natural spawning fall chinook salmon spawners of 1,064 fish should have produced a mean number of recruits of 5,062 fish, even assuming low marine survival. However, the observed mean was only 3,815 adult fall chinook recruits (SaSI 2003). Neither hatchery employs weirs that hinder or block migration of the natural-origin chinook salmon population. Screens at water intake and discharge structures at the hatcheries comply with NMFS' criteria (Nisqually 2003a; 2003b).

6.2.26.5 VSP Effects. The fall chinook population produced by the two Nisqually Tribal hatcheries may have a neutral to beneficial effect on the abundance, diversity and spatial structure of the reference Nisqually natural chinook population. The transplanted Green River lineage hatchery stock produced by the programs may have supplanted any native fall chinook stock historically present in the watershed. The localized Clear Creek and Kalama Creek hatchery population is viewed as the best stock for re-establishing a self-sustaining fall chinook population in the watershed (PS TRT 2003). Stock assessment and hatchery fish survival data suggest that escaping hatchery-origin fish have been contributing to, if not sustaining, the abundance of the naturally spawning population in the Nisqually River. The effects of the hatchery programs on the abundance of natural-origin fall chinook are unknown. Allozyme analysis of naturally-spawning chinook in several upper Nisqually River tributaries showed that they are similar to Green River chinook and their hatchery derivatives (including the Nisqually hatchery population) (SaSI 2003). Best management practices are applied through the programs to maintain the diversity of the propagated populations. The program is inadvertently benefiting the spatial structure of the Nisqually population via straying of adult fish from the hatchery release sites into the mainstem Nisqually River and its upper tributaries. The program's effects on productivity are unknown, but the poor abundance status of the natural-origin population indicates that the natural population's productivity in the extant natural environment is poor, and that contributions (at unknown levels) by naturally spawning hatchery fish are not leading to improved natural fish productivity. NMFS (2003) reported a short term λ for the composite (hatchery and natural chinook) Nisqually population of 1.04. In developing this estimate, it was assumed that the reproductive success of naturally spawning hatchery fish was equivalent to that of natural fish. Long and short term population trend estimates calculated on all spawners were 1.02 and 1.06 respectively (NMFS 2003). If habitat conditions in the Nisqually River watershed and in the estuary are limiting to natural chinook productivity (Nisqually 1999), the two hatchery

programs provide an important means to artificially sustain the extant Nisqually population until habitat limiting factors are remedied.

6.2.27 Tumwater Falls Hatchery Fall Chinook

6.2.27.1 Broodstock/Program History. The hatchery program (described in two HGMPs, one describing subyearling fall chinook production, the other describing the yearling fall chinook production component) was founded beginning in 1946 and extending through 1992 using Green River hatchery-lineage broodstock transferred from WDFW hatcheries in Puget Sound. Soos Creek Hatchery-origin fingerlings were the first hatchery fish transferred into the lower river, with 16 different hatchery populations or admixtures of populations used to sustain juvenile fish production (Crawford 1999). The first fall chinook egg takes in the watershed resulting from adult returns occurred in 1949 (threes) and 1950 (threes and fours) (WDF 1949; 1950), and the program was made to be fully self-sustaining and based on on-station broodstock collections under WDFW's Fish Transfer Policy in 1993. The program is located in an area where no self-sustaining, native chinook population existed (PS TRT 2003), due to the blockage of habitat features needed to sustain anadromous salmon populations by impassable falls at the mouth of the Deschutes River. The hatchery population has been sustained predominately by juvenile hatchery fish releases, but the progeny of hatchery-origin fall chinook adults deemed surplus to broodstock needs and periodically allowed to spawn naturally upstream of Tumwater Falls may also contribute adult fish as broodstock. The program is geographically, ecologically, and genetically disconnected from the Green River natural, and Green River hatchery lineage, populations originally used to found the Tumwater Falls hatchery population. There has been no use of natural-origin fish in the hatchery broodstock, especially no Green River Basin wild chinook, which differentiates them, and should cause higher divergence, from their Green River ancestry (A. Marshall, WDFW, pers. comm., April 2004). No measures have ever been applied in the Tumwater Falls Hatchery program to maintain the ecological and genetic characteristics of the Green River natural population, or of the transplanted Green River hatchery lineage populations used to found and sustain the propagated population. Potential ecological risks to natural chinook salmon populations in Puget Sound marine areas posed by juvenile fall chinook releases by the Tumwater Falls Hatchery program may be partially addressed through adjustments in fish release size and timing practices.

6.2.27.2 Similarity of Hatchery Origin to Natural Origin Fish. The transplanted, isolated hatchery population propagated through the Tumwater Falls Hatchery program is likely to be substantially diverged from natural chinook salmon populations in the region, and is not considered to be part of the Puget Sound chinook salmon ESU. The deep South Sound inlet region where the program operates does not have a native self-sustaining natural chinook salmon population that would serve as an appropriate reference population for the hatchery program (SaSI 2003; PS TRT 2003). Fall chinook returns to the Deschutes River were introduced, and predominately sustained by, annual Tumwater Falls Hatchery juvenile fish production (WDFW 2003t; Crawford 1999). No genetic samples have been collected from the Tumwater Falls Hatchery fall chinook population to allow for its comparison with other Puget Sound chinook

salmon populations. The program's stock transfer history indicates that the hatchery population is related to other transplanted Green River lineage hatchery populations, and distinct from other TRT-delineated chinook salmon populations in the ESU (Marshall et al., 1995; SaSI 2003).

6.2.27.3 Program Design. The program is designed to provide chinook salmon for recreational in Puget Sound marine areas and Tribal fisheries harvest in the deep South Sound, including Budd Inlet (WDFW 2003t; 2003u). Subyearling and yearling fall chinook releases are 100 percent adipose fin clipped prior to release, with a proportion also receiving coded wire tags for fisheries contribution and smolt-to-adult survival assessment purposes (WDFW 2003t; 2003u). Best management practices are applied in the implementation of the program to produce adult fish for isolated harvest purposes, as detailed in the two HGMPs for Tumwater Falls Hatchery operations (WDFW 2003t; 2003u). Hatchery practices are generally consistent with measures described for isolated programs in Appendix I.

6.2.27.4 Program Performance. The program intent is to isolate hatchery production from natural chinook populations to provide adult fish for harvest. The location of the hatchery program in an area well removed from natural chinook populations, and hatchery management measures applied to sustain a localized population in the Deschutes River suggest that the program is meeting its isolated intent (Suquamish 2003). For brood years 1985 through 1987, smolt-to-adult survival rates for fish released through the program averaged 0.91 percent (range from 0.05 percent to 2.61 percent) for subyearlings (WDFW 2003t), and 0.7 percent for yearlings (brood year 1986-95 average, excluding 1987 and 1993) (WDFW 2003u). The 1997-2001 arithmetic mean total spawner escapement to the Tumwater Falls Hatchery complex is 5,500 adult fish (WDFW 2003h) and the mean number of hatchery-origin adult fall chinook passed upstream in the Deschutes River to spawn naturally for the same period is 763. The Tumwater Falls program has led to the production of natural origin fall chinook in the Deschutes River through allowances for transplanted stock hatchery-origin fish to spawn naturally at variable levels (0 adults to several thousand each year) (Crawford 1999; Fuss 2003). Three years of juvenile out-migrant sampling studies by WDFW in the Deschutes River indicates that hatchery-origin fall chinook released upstream to spawn naturally have deposited egg to out-migrant survival rates ranging from 3 percent to 14 percent (Fuss, 2003). The ability of a out-of-basin origin fall chinook population to sustain itself naturally in the Deschutes River watershed is unknown. Juvenile fish released through the program are mass marked with adipose fin clips, and a proportion also receive coded wire tags, allowing for continued assessments of hatchery fish contribution and stray rates into natural spawning areas (WDFW 2003t; 2003u). The progeny of naturally spawning hatchery fall chinook have also been marked with coded wire tags to evaluate their contribution to adult returns (Fuss 2003). The program is proposed to be operated indefinitely to provide fall chinook adults for harvest opportunity. There are no blockages or screen associated with the program that harm TRT-delineated extant natural chinook salmon populations.

6.2.27.5 VSP Effects. The fall chinook salmon population produced by the Tumwater Falls Hatchery program is expected to have a neutral effect on the viability of TRT-delineated

populations within the ESU. The propagated species and population is not native to the Deschutes River, and the Tumwater Falls population is considered not representative of any extant Puget Sound chinook salmon population. The program may contribute to the total abundance of naturally spawning fall chinook salmon that resemble other Green River hatchery lineage fall chinook. The allowance for natural spawning in the watershed is subject to the availability of surplus adult returns at the Tumwater Falls broodstock collection facility. Natural spawning may occur in the lower 15 miles of the Deschutes River, pending handling and passage of adult fish upstream of a broodstock collection facility above Tumwater Falls, which has been haphazard since the program's inception (Crawford, 1999). Tumwater Falls Hatchery-origin fall chinook that successfully spawn naturally in the Deschutes River and in Percival Creek (a tributary to Capital Lake) may contribute to the ESU-wide abundance of natural origin fish similar to Green River stock chinook. Natural-origin fall chinook salmon produced through the program may benefit total abundance of Green River hatchery lineage fall chinook salmon within the ESU, but not the diversity, spatial structure or productivity any natural chinook populations. The Tumwater Falls Hatchery population is localized through 58 years of propagation at the hatchery site to ecological conditions in the Deschutes River watershed and deep south Sound, and has been geographically isolated from the natural Green River population since its inception in 1946. No measures have been applied in the hatchery program to maintain the genetic or ecological characteristics of the original founding Soos Creek Hatchery population, or of that hatchery's donor Green River natural population. Due to the hatchery's location, natural spawning by Tumwater Falls Hatchery fall chinook occurs outside of the natural range of any natural Puget Sound chinook populations, so the spatial structure of the natural populations within the ESU is not benefiting from the program. Stray fall chinook adults produced through the program do not contribute to natural spawning in watersheds where extant natural populations are located, and any benefits to the productivity of populations within the ESU are unlikely.

6.2.28 George Adams Hatchery Fall Chinook/Ricks Pond Fall Chinook

6.2.28.1 Broodstock/Program History

There are two hatchery programs managed by WDFW and a non-governmental cooperative group that propagate the same hatchery fall chinook population in the lower Skokomish River watershed. WDFW's George Adams Hatchery has released transplanted Green River hatchery lineage fall chinook salmon subyearlings into Purdy Creek, a tributary to the lower Skokomish River, since 1961 (WDFW 2003v). The privately operated, but WDFW administered Ricks Pond relies on broodstock collections at George Adams Hatchery, and has released the yearling fall chinook into the lower Skokomish River at river mile 2.9 since the 1996 brood year (WDFW 2003w). Recent adjustments to the programs that are beneficial to natural chinook population viability include mass marking of fish released from the hatcheries to assess their contribution to natural spawning in the Skokomish River. 2003). If stray levels for returning adult hatchery origin fall chinook salmon are determined through mark recovery and genetic evaluations to be detrimental to the extant natural production in the Skokomish River, program reform measures that would lead to less risk to natural chinook salmon viability could include reduction of

juvenile fish release levels, changes in fish release locations, and a change in the broodstock used in the program to one that is of native, local origin.

The hatchery fall chinook population propagated through the program was established in Purdy Creek, where no fall chinook population previously existed (WDFW 1957), through transfers of Green River hatchery lineage chinook salmon populations localized to other WDFW hatcheries, including Hoodsport Hatchery (WDFW 2003v). The present program uses hatchery-origin fall chinook return volunteering to Purdy Creek and George Adams Hatchery as broodstock. George Adams Hatchery continues to receive fall chinook broodstock transferred from Hoodsport Hatchery (WDFW 2003o). The hatchery population is considered substantially diverged from natural Puget Sound chinook salmon populations and has been designated as an out-of-ESU population (SSHAG 2003).

6.2.28.2 Similarity of Hatchery Origin to Natural Origin Fish. The hatchery population propagated through the program is considered to be substantially diverged from natural chinook populations in Puget Sound (SSHAG 2003) and out of the ESU. The reference TRT population for the program is the Skokomish population. The George Adams Hatchery population is not part of that natural population (not in the ESU). However, monitoring and evaluation suggests that escaping hatchery-origin fish have been sustaining the abundance of the extant naturally spawning Skokomish population (SaSI 2003). Although not the intent of the programs, they are likely increasing the number of naturally spawning chinook salmon in the mainstem Skokomish River through straying (WDFW 2003o; SaSI 2003). The Rick's Pond program releases yearling fall chinook near the mouth of the Skokomish River, and returning adult fall chinook produced through the program are not collected at the hatchery release site. It is likely that adult fish that are not harvested in fisheries stray into the Skokomish River to spawn. Mark sampling in the Skokomish River in 1998 showed that hatchery-origin fish comprised at least 43 percent of the total number of fall chinook sampled in the river (WDFW 2003v). Marshall et al., (1995) acknowledged that the Hood Canal hatcheries were the primary source of naturally spawning fall chinook in the Hood Canal region rivers. Allozyme analysis results to date suggest that there is no significant genetic differentiation between Skokomish natural chinook spawners and the George Adams and Hoodsport hatchery populations (SaSI 2003).

6.2.28.3 Program Design. The programs are described as isolated harvest programs, designed to provide chinook salmon for commercial and recreational fisheries harvests. As noted above, an unknown but significant proportion of the total annual naturally spawning chinook population in the Skokomish River are hatchery-origin strays, which calls to question whether the programs can be considered isolated. Approximately 11 percent of the 3.8 million subyearling fall chinook released from George Adams Hatchery are marked with adipose fin clips and/or coded wire tags (WDFW 2003v). All yearlings released from Rick's Pond are identified with a differentiating mark (e.g., adipose fin clip or otolith mark). Best management practices are applied in implementing the programs, as detailed in the two HGMPs to reduce the programs' ecological, genetic, and demographic effects on natural chinook salmon (WDFW 2003v; 2003w). Hatchery practices are generally consistent with measures described for integrated programs in Appendix

I, with hatchery fall chinook straying into Skokomish River natural spawning areas a notable exception. The proportion of natural fall chinook incorporated as broodstock at the hatchery each year is unknown, but is likely low given the off-channel and lower river location of the hatchery broodstock collection site.

6.2.28.4 Program Performance. The intent of the programs is to isolate hatchery production from natural chinook populations. The estimated 1988-96 brood year average smolt-to-adult survival rate for George Adams Hatchery fall chinook was 0.22 percent (range 0.1 percent to 0.84 percent). The survival rate goal for the Rick's Pond program is 2 percent, but the smolt-to-adult survival rate for the one year for which data is available (1995) was 0.45 percent (WDFW 2003w). Estimated total brood year 1988-96 adult contribution to all fisheries and escapement for the George Adams hatchery program averaged 3,987 (range 452 to 15,215). The 1995-1999 arithmetic mean total spawner escapement to the George Adams Hatchery trap is 5,828 adult fish (WDFW 2003v). The annual contribution of the hatchery programs to natural spawning in the Skokomish River is unknown, but available data for several years indicates that straying by hatchery fish, likely from these two programs, is substantial. Juvenile fish released through the program are now marked to allow for assessments of hatchery fish contribution and stray rates into natural spawning areas. The programs are proposed to be operated indefinitely to provide fall chinook adults for harvest opportunity. There are no blockages or screen associated with the programs that are likely to harm natural chinook salmon populations.

6.2.28.5 VSP Effects. The fall chinook population propagated by the George Adams and Ricks Pond hatchery programs may have a slightly negative effect on VSP parameters for TRT-delineated chinook salmon populations within the ESU. Although not the intent of the programs, the programs are increasing the number of naturally spawning chinook salmon in the mainstem Skokomish River through straying. VSP parameters for natural chinook in the ESU do not benefit from this program, as the hatchery stock is substantially diverged from, and not representative of, any extant Puget Sound chinook population. Noteworthy is that hatchery-origin fall chinook comprise a substantial proportion of the naturally spawning Skokomish population, which is presumably used as the standard for determining the ESU status of the George Adams Hatchery population.

6.2.29 Hoodsport (Finch Creek) Hatchery Fall Chinook

6.2.29.1 Broodstock/Program History. There are two WDFW hatchery programs that propagate the same hatchery fall chinook population for release into Finch Creek, a westside Hood Canal tributary in the town of Hoodsport. The two programs have released out-of-basin origin subyearling and yearling fall chinook salmon at the hatchery location since 1953 and 1995, respectively (WDFW 2003x; 2003y). Recent adjustments to the programs that may be beneficial to natural chinook population viability include planned mass marking of fish released from the hatchery (subject to approval by the Point No Point Treaty Tribes) to assess hatchery fall chinook contribution to natural spawning in westside Hood Canal tributaries and the Skokomish River. Potential hatchery reform measures for this program could include reductions in total fall

chinook subyearling and yearling release numbers as measures to reduce adult fish straying levels to neighboring natural production areas in the sub-region. Juvenile fish release reductions may also act to reduce food resource competition and predation risks to natural-origin chinook salmon present in Hood Canal marine areas.

The hatchery fall chinook population propagated through the program was established in Finch Creek, where no independent fall chinook population previously existed (PS TRT 2003), through transfers of Green River hatchery lineage chinook salmon populations localized to other WDFW hatcheries, including Soos Creek Hatchery, Dungeness Hatchery, Voights Creek Hatchery, and Minter Creek Hatchery (WDFW 2003x). Localized adult returns to the hatchery release site have been used to sustain the Hoodsport Hatchery fall chinook programs since 1993, and the present program uses hatchery-origin fall chinook volunteering to Finch Creek as broodstock. The hatchery population is considered substantially diverged from natural Puget Sound chinook salmon populations and has been designated as an out-of-ESU population (SSHAG 2003).

6.2.29.2 Similarity of Hatchery Origin to Natural Origin Fish. The hatchery population propagated through the programs is considered to be substantially diverged from natural chinook populations in Puget Sound (SSHAG 2003) and out of the ESU. The reference TRT populations for the programs are Skokomish and Mid Hood Canal. The Hoodsport Hatchery population is not part of these natural populations (not in the ESU). Monitoring and evaluation suggests that escaping hatchery-origin fish have been contributing to the abundance of the naturally spawning population in Hood Canal watersheds, including the Skokomish River (Vander Haegen and Doty 1995; WDFW 2003x). The programs may therefore be inadvertently increasing the number of naturally spawning chinook salmon in the mainstem Skokomish River through straying. Mark sampling in the Skokomish River in 1998 showed that hatchery-origin fish comprised at least 43 percent of the total number of fall chinook sampled in the river (WDFW 2003v). In 1998, 61 chinook spawners were sampled for marks or tags, and ten of the fish sampled carried coded wire tags (WDFW 2003x). The tagged fish originated from George Adams Hatchery (n=3), Hoodsport Hatchery (n=2), Rick's Pond (n=4), and the discontinued Sund Rock Net-pens (n=1). Seven of the fall chinook adults sampled were identified as hatchery fish that had been released as yearlings, and three were subyearling origin. Scale analysis of the untagged adults in the 1998 sample showed that an additional 16 fish had hatchery yearling fall chinook scale patterns. Marshall et al., (1995) acknowledged that the Hood Canal hatcheries were the primary source of naturally spawning fall chinook in the Hood Canal region rivers. Allozyme analysis results to date suggest that there is no significant genetic differentiation between Skokomish natural chinook spawners and the George Adams and Hoodsport hatchery populations (SaSI 2003).

6.2.29.3 Program Design. The programs are isolated harvest programs, designed to provide chinook salmon for commercial and recreational fisheries harvests. As noted above, an unknown but significant proportion of the total annual naturally spawning chinook population in the Skokomish River are hatchery-origin strays, which calls to question whether the programs can be considered isolated. Best management practices are applied in implementing the programs, as detailed in the two HGMPs to reduce the programs' ecological, genetic, and demographic effects

on natural chinook salmon (WDFW 2003x; 2003y). Hatchery practices are generally consistent with measures described for integrated programs in Appendix I, with hatchery fall chinook straying into Skokomish River natural spawning areas a notable exception. The proportion of natural fall chinook incorporated as broodstock at the hatchery each year is unknown, but is likely low given that the hatchery release site is located at the mouth of a small creek that historically lacked chinook salmon.

6.2.29.4 Program Performance. The intent of the programs is to isolate hatchery production from natural chinook populations. The estimated 1989-94 brood year average smolt-to-adult survival rates for Hoodsport Hatchery fall chinook were 0.26 percent for subyearlings and 0.45 percent for yearlings (1994-96 brood years only) (WDFW 2003x; 2003y). The 1995-2001 arithmetic mean total spawner escapement to the Hoodsport Hatchery trap is 4,993 adult fish (range 3,190 to 11,646 fish) (WDFW 2003x). The annual contribution of the hatchery programs to natural spawning in the Hood Canal region is unknown, but available data for several years indicates that straying by hatchery fish, including adults produced by Hoodsport Hatchery, is substantial. Juvenile fish released through the program are marked to allow for assessments of hatchery fish contribution and stray rates into natural spawning areas. The programs are proposed to be operated indefinitely to provide fall chinook adults for harvest opportunity. There are no blockages or screen associated with the programs that are likely to harm any independent natural chinook salmon populations.

6.2.29.5 VSP Effects. The Hoodsport Hatchery fall chinook population may have a neutral effect to slightly negative effect on VSP parameters for independent chinook salmon populations within the ESU. The abundance, diversity, spatial structure and productivity of naturally spawning and natural-origin Puget Sound ESU chinook salmon populations does not benefit from the programs, as the Hoodsport Hatchery population is substantially diverged from, and not representative of, any extant Puget Sound chinook population (SSHAG 2003).

6.2.30 Hamma Hamma (WSC) Hatchery Fall Chinook

6.2.30.1 Broodstock/Program History. The Long Live the King's (LLTK) Hamma Hamma Hatchery has released transplanted hatchery lineage fall chinook salmon subyearlings into the Hamma Hamma River watershed, a westside Hood Canal tributary, since 1995 (LLTK 2003). The privately operated, WDFW cooperative, program was founded using Green River hatchery lineage fall chinook as broodstock. Recent adjustments to the program that are beneficial to natural chinook population viability include collection of 50 percent of adult fish used as broodstock each year from fall chinook returns to the Hamma Hamma River, and mass and differential marking of fish produced from the two broodstock sources released from the hatchery to assess their contribution to natural spawning in the Skokomish River. 2003). If stray levels for returning adult hatchery origin fall chinook salmon are determined through mark recovery and genetic evaluations to be detrimental to the extant natural production in the Skokomish River, program reform measures that would lead to less risk to natural chinook salmon viability could include reduction of juvenile fish release levels, changes in fish release

locations, and a change in the broodstock used in the program to one that is of native, local origin.

The hatchery fall chinook population propagated through the program was founded through transfers from George Adams Hatchery. The section describing the broodstock history for that WDFW program applies for the Hamma Hamma Hatchery population. The present program continues to use hatchery-origin fall chinook return volunteering to George Adams Hatchery, and adult fish collected from the Hamma Hamma River using seines and hook and line (LLTK 2003). Like the George Adams Hatchery population, the Hamma Hamma hatchery population is considered substantially diverged from natural Puget Sound chinook salmon populations and has been designated as an out-of-ESU population (SSHAG 2003).

6.2.30.2 Similarity of Hatchery Origin to Natural Origin Fish. The hatchery population propagated through the program is considered to be substantially diverged from natural chinook populations in Puget Sound (SSHAG 2003) and out of the ESU.

The reference TRT population for the program is the Mid Hood Canal population. Genetic and life history evidence indicates that the indigenous spawning aggregation in the Hamma Hamma River has been replaced by introduced Green River lineage hatchery stock which does not represent the historical population (i.e., the native population is likely genetically extinct) (PS TRT 2004). Consequently, the chinook salmon population in the river no longer represents the historical population and components of the historical genetic and life history diversity important to the viability of chinook salmon in this basin probably have been lost. The Hamma Hamma population is not part of that natural population (not in the ESU). Genetic characterization of Mid-Hood Canal chinook has been limited to comparison of adults returning to the Hamma Hamma River in 1999 with other Hood Canal and Puget Sound populations (SaSI 2003). These studies, although not conclusive)additional genetic data were collected in 2000 and 2001), suggest that Hamma Hamma fall chinook returns are not genetically distinct from the Skokomish chinook population, or from George Adams and Hoodport Hatchery populations used as broodstock for the Hamma Hamma Hatchery program (SaSI 2003, citing unpublished data from Anne Marshall, WDFW). Straying of chinook originating from southern Hood Canal and hatchery releases into the Mid Hood Canal rivers were considered potential contributing causes of these genetic similarities. Monitoring and evaluation indicates Hamma Hamma Hatchery-origin fall chinook adults are likely increasing the number of naturally spawning chinook salmon in the Hamma Hamma River (SaSI 2003).

6.2.30.3 Program Design. The program is described as an integrated recovery program (LLTK 2003), but the hatchery population used as the supplementation stock for the program was designated as substantially diverged from any natural Puget Sound chinook salmon populations (SSHAG 2003) and therefore not part of the Puget Sound chinook salmon ESU. It is likely that a significant proportion of the total annual naturally spawning chinook population in the Hamma Hamma River originates directly from this hatchery program. Juvenile fish released through the program are mass marked with adipose fin clips, and fish originating from the two broodstock sources (George Adams Hatchery transfers and Hamma Hamma origin fish) are differentially

otolith marked (LLTK 2003). Hatchery practices are generally consistent with measures described for integrated programs in Appendix I, with the exception of the continued use of broodstock transferred from George Adams Hatchery in the Skokomish watershed to sustain ½ of the program. Best management practices are applied in implementing the program, as detailed in the HGMP (LLTK 2003) to minimize ecological and demographic effects on natural chinook salmon. Genetic effects on the extant natural population in the Hamma Hamma River (a segment of the TRT delineated Mid Hood Canal independent chinook population) associated with supplementation using an out-of-watershed origin hatchery population are unclear.

6.2.30.3 Program Performance. The intent of the program is to supplement natural spawning by the Mid Hood Canal chinook population in the Hamma Hamma River. Smolt-to-adult survival rate data are not yet available for the program (LLTK 2003). Preliminary data from otolith mark recoveries of brood year 1995 program fish escaping to the Hamma Hamma River indicates a survival to adult return of about 1 percent, or 400 adults for a 40,000 smolt release (LLTK 2003). Assuming that the majority of escaping hatchery-origin adults for the 1995 brood year were four year old fish, fall chinook produced by the program may have comprised 72 percent of the total naturally spawning population in the Hamma Hamma River in 1999 (557 fish). Escapement to the Hamma Hamma River has increased coincident with the first adult returns from the program (1998) (SaSI 2003). However, the annual contribution of the hatchery program to natural spawning in the Hamma Hamma River, and to the abundance of natural-origin chinook, are unknown, and pending continued stock assessment and mark recovery evaluations by LLTK and the co-managers. Juvenile fish released through the program are mass marked to allow for continued assessments of hatchery fish contribution to natural spawning areas and fisheries. The program is proposed to be operated for a 12 year maximum duration to supplement the naturally spawning chinook population in the Hamma Hamma River. There are no structures associated with program broodstock collection or hatchery operation that are likely to block or hinder migration by the Hamma Hamma natural chinook salmon population. Screens used by the hatchery program at water intakes and discharge locations are also unlikely to harm natural chinook salmon.

6.2.30.5 VSP Effects. The reference natural populations for the Hamma Hamma program are the Mid Hood Canal population (the supplemented population, and source for ½ of annual broodstock) and the Green River population (the original founding population for the George Adams hatchery population). The intent of the Hamma Hamma program is to supplement and rebuild the naturally spawning fall chinook population in the Hamma Hamma River. The program appears to be successfully increasing the abundance of natural spawners in the river, which is one of three westside Hood Canal watersheds where the Mid Hood Canal chinook population is present. However, VSP parameters for this independent natural-origin population do not benefit from this program, as the Hamma Hamma Hatchery population (like the George Adams Hatchery population) was determined to be substantially diverged from, and not representative of, any extant Puget Sound chinook population (SSHAG 2003). More information is needed on the genetic and demographic relationships between the extant spawning aggregation and Mid Hood Canal population identified by the Puget Sound TRT, and the role historical and

present diversity groups may have had, or may have, in the viability of chinook salmon in the river basin area (PS TRT 2004).

6.2.31 Big Beef Creek Hatchery Fall Chinook

6.2.31.1 Broodstock/Program History. The Big Beef Creek Hatchery program was terminated in May, 2004 by WDFW, UW, and the Hood Canal Salmon Enhancement Group (HCSEG) (K. Dimmit, WDFW pers. comm., May 2004). The following discussion therefore pertains to remaining the juvenile, sub-adult, and adult hatchery population now rearing in marine areas that was produced by the program through the 2004 release year, and returning to the creek through 2008.

The UW/WDFW and HCSEG program is located in a small northern Hood Canal tributary on the East Kitsap Peninsula. Subyearling fish were released through the program from 1972 through 2004. The hatchery population was founded beginning in 1972 by, and through 1993 annually relied on, transfers of fall chinook that were the progeny of Green River lineage broodstock collected at WDFW's Hoodspout and George Adams hatcheries (UW 2003b). The program began using localized adult fall chinook returns to the Big Beef Creek Hatchery trap in 1993, and only adult fall chinook returns to the trap were used to sustain the hatchery programs in subsequent years. The program is located in an area where no self-sustaining, native chinook population existed (PS TRT 2003), and where habitat features needed to sustain a natural chinook population are absent, and not historically present. The hatchery population has been sustained entirely by juvenile hatchery fish releases, and there is little or no production of natural-origin adults through natural spawning by hatchery fish in Big Beef. The program is geographically, ecologically, and genetically disconnected from the extant Green River natural and hatchery populations originally used (through transfers from other hatcheries) to found the hatchery population. There has been no use of natural-origin fish in the hatchery broodstock, especially no Green River Basin wild chinook, which differentiates them, and should cause higher divergence, from their Green River ancestry (A. Marshall, WDFW, pers. comm., April 2004). No measures have ever been applied in the hatchery programs to maintain the ecological and genetic characteristics of the founding Green River natural or hatchery lineage populations.

6.2.31.2 Similarity of Hatchery Origin to Natural Origin Fish. The transplanted, isolated hatchery population propagated by the hatchery program is likely to be substantially diverged from natural chinook salmon populations in the region, and is not considered to be part of the Puget Sound chinook salmon ESU. The hatchery stock has been under domestication for 32 years at its location, using a transplanted Green River-lineage hatchery stock (the George Adams Hatchery population) that has been designated by NMFS as being substantially diverged from natural Puget Sound chinook populations (SSHAG 2003). Allozyme analyses in 2000 showed that Big Beef Creek Hatchery fall chinook are highly divergent genetically from six Hood Canal area, and eight south Puget Sound area, naturally spawning and hatchery populations, including the Soos Creek Hatchery population. Other genetic analyses suggested that the hatchery population at the time of sampling included fish of differing origins. High temporal variability

observed in the population could be due to the low number of broodstock spawners used in some years at the hatchery (A. Marshall, WDFW, pers. comm., April, 2004). The watershed where the program is located does not have a native self-sustaining chinook salmon population (SaSI 2003; PS TRT 2003). Chinook returns to the area were introduced to, and are sustained by, annual juvenile fish releases by the programs. Genetic data, and the program's stock transfer history indicate that the hatchery fish population is most related to other transplanted Green River lineage hatchery populations, and distinct from other TRT-delineated chinook salmon populations in the ESU (Marshall et al., 1995; SaSI 2003).

6.2.31.3 Program Design. The program was designed to isolate out-of-basin origin hatchery fish from native chinook populations in the Hood Canal sub-region, providing fall chinook for harvest in fisheries (UW 2003b). The program also was operated as an educational venue for local schools interested in salmon biology. Subyearling fall chinook released through the program were not consistently marked to allow for their identification in fisheries and as escaping adults (UW 2003b). Best management practices were applied in the implementation of the program to produce adult fish for harvest, as detailed in the HGMP for the program (UW 2003b). Hatchery practices were generally consistent with measures described for isolated harvest programs in Appendix I.

6.2.31.4 Program Performance. The program was intended primarily to produce juvenile fall chinook, and adult fish for harvest, in an area isolated from natural chinook populations. The location of the hatchery program in a watershed presently and historically lacking a natural chinook population, and hatchery protocols applied to foster a self-sustaining, localized hatchery population are consistent with the programs' isolated intent. Due to the lack of an identifying mark or tag on fish released at Big Beef Creek Hatchery total smolt-to-adult survival rates for fish released through the program are unknown. The 1995-1999 arithmetic mean number of adult fall chinook salmon escaping to the Big Beef Creek Hatchery weir and collected as broodstock was 214 fish (UW 2003b). The annual broodstock collection goal for the program is 140 adult fish. Very few to none of the adult fish returning to Big Beef Creek spawn naturally due to the small, intertidal nature of the 0.1 miles of creek available for spawning downstream of the hatchery weir, and the exclusion of fall chinook spawners above the weir as a measure to reduce redd superimposition risks to summer chum salmon spawners (WDFW and PNPTT 2000). Stray rates of adult fish to watersheds where native chinook populations exist are unknown. Juvenile fish released through the program have not been marked, and assessments of hatchery fish contribution and stray rates are not feasible. The program was terminated in 2004. There are no blockages or screens associated with the program that will harm any independent natural chinook salmon population.

6.2.31.5 VSP Effects. The Big Beef Creek Hatchery fall chinook salmon population produced by this program may have a neutral or slightly negative positive effect on VSP parameters for independent natural chinook population. The information presented above for the George Adams Hatchery and Hoodport Hatchery populations regarding VSP parameter effects applies for this hatchery population. The hatchery is located on a tributary to Hood Canal that lacks a self-

sustaining natural-origin chinook salmon population (NMFS 2003), and the program has no significant contributions to natural spawning. Very few fall chinook produced by the hatchery spawn naturally due to the small areal extent, and intertidal nature of spawning habitat available to returning fish in the 0.1 miles of creek downstream of the Big Beef Creek weir. If first generation Big Beef Creek Hatchery-origin fall chinook successfully spawn naturally in the 0.1 miles of available natural habitat downstream of the hatchery weir, the program may potentially benefit total abundance of natural-origin chinook similar to Green River hatchery fish present within the ESU. Measures were applied at the hatchery to maintain the diversity of the propagated population. However, no measures have been applied in the program to maintain the genetic or ecological characteristics of the original founding Green River-derived hatchery stocks. It is unlikely that this hatchery population will benefit VSP parameters for any extant natural Puget Sound chinook population.

6.2.32 Dungeness Hatchery Chinook

6.2.32.1 Broodstock/Program History. The program was initiated in 1992 as an integrated recovery effort to preserve and increase the abundance of the native spring chinook salmon population in the Dungeness, which had declined to critically low abundance levels (a 1988-97 average population size of 156 fish) (NFRB 1995; WDFW 2003z; SaSI 2003). Methods applied in the program, including production of different chinook life stages for release and dispersal of juvenile fish into the upper watershed should benefit the viability of the Dungeness natural chinook population. Juvenile fish produced through the hatchery program are mass marked via thermally induced otolith banding, or through application of blank or coded wire tags (WDFW 2003z).

Native spring chinook used to establish the program were obtained in brood years 1992-95 through extraction of eyed eggs or pre-emergent fry using a hydraulic redd sampler from known chinook salmon redds constructed by naturally spawning fish in the Dungeness River (WDFW 2003z). Juvenile fish removed from the redds were transferred to Hurd Creek Hatchery (a Dungeness Hatchery satellite facility) for rearing and retention as a captive broodstock. Captive broodstock for the program were also reared at the Squaxin Net-pens in south Puget Sound. Mature captive brood adult chinook produced through the program have provided the only egg source since 1996. The objective of the program was to establish a captive brood chinook population based on extant representative chinook families collected from the Dungeness River as an emergency measure to prevent extinction of the population. Captive brood adults that are progeny of natural spawners are raised at Hurd Creek Hatchery (a Dungeness satellite facility) to adult size and spawned. The progeny of spawners are released as fry, fingerlings, or subyearlings into Dungeness River watershed areas, including the Grey Wolf River, where natural spawning historically occurred to supplement juvenile fish production by the naturally spawning population (WDFW 2003z).

6.2.32.2 Similarity of Hatchery Origin to Natural Origin Fish. The captive broodstock population was derived directly from naturally spawning Dungeness chinook salmon families

over four brood years, and there are no differences between the natural and hatchery populations (SaSI 2003). The hatchery population is considered fully representative of, and integrated with, the natural Dungeness chinook population. No examinations of the genetic relationship between the Dungeness chinook populations and other chinook populations in Puget Sound have been made (SaSI 2003). The hatchery population is currently listed as protected under the ESA with its founding Dungeness natural population. Hatchery-origin and natural-origin spring chinook salmon share identical life history characteristics for the majority of the natural chinook salmon life cycle, including: rearing to smolt size in the Dungeness River watershed (fingerling hatchery releases); seaward emigration in the Dungeness River predominately as subyearling smolts during the spring and summer months (WDFW 1997; D. Seiler, unpublished juvenile outmigrant trapping data, 1997); early rearing in Dungeness Bay and Strait of Juan de Fuca Sound nearshore marine areas; emigration into Washington and southern British Columbia pelagic marine areas; rearing for two to five years from smolt-to-adult size in Northeast Pacific marine waters, including Puget Sound; migration through British Columbia and Washington marine waters as maturing two to six year old adults in the summer months; and freshwater entry and spawning in the Dungeness River watershed in August and September (NFRB 1995; SaSI 2003; WDFW 2003z). On the other hand, the hatchery-origin fish are the progeny of captive broodstock parents that are artificially spawned, and are incubated and reared in a hatchery under controlled conditions for five to seven months rather than being deposited as eggs in gravel reaches and rearing to smolt size in the Dungeness River natural environment. Monitoring and evaluation of the genetic and ecological effects of the program are ongoing (WDFW 2003z; WDFW 2001), and data collected will be used to adjust the hatchery program to meet its fish production and conservation objectives (WDFW 2003z).

6.2.32.3 Program Design. The program is specifically designed to preserve the native North Fork Nooksack spring chinook population, increasing prospects for its recovery to a viable, self-sustaining level. The program has been successful in increasing the number of naturally spawning spring chinook salmon in the North Fork Nooksack River (WDFW 2003a; Castle et al., 2002). Adults originating from the program have comprised greater than 50 percent of the total naturally spawning population since 1996 (Castle et al., 2002). Mass marking of hatchery spring chinook with coded wire tags and using otolith marks has allowed for assessments to be made of stray levels of hatchery fish to watersheds outside of juvenile fish release sites. Most returning adults have been recovered in the North Fork Nooksack River basin (Castle et al., 2002; Kirby). However, a proportion of the annual adult returns were also recovered in the South Fork Nooksack River. An estimated 24 percent to 44 percent of the total number of spring chinook spawners in the South Fork Nooksack River in 1999-2001 were strays, predominately from the Kendall Creek Hatchery program (Kirby 2002).

Best management practices are applied in implementing the program that are designed to benefit the abundance, diversity, spatial structure, and productivity of the natural and propagated populations (WDFW 2003z). Hatchery management practices are consistent with measures described for integrated programs in Appendix I, and with captive broodstock program standards presented in NMFS (1999). Specific measures implemented to minimize adverse genetic,

ecological, and demographic effects on listed fish, including those under propagation at the hatchery, are included in the Dungeness Hatchery HGMP, which describes hatchery fish production, monitoring and evaluation, and research actions (WDFW 2003z). Sections 6, 7, 8, and 9 of the HGMP describe broodstock management, mating, and juvenile fish rearing and release measures applied to minimize the risk of within and among population diversity loss to the donor listed, and artificially propagated, chinook salmon populations. Measures implemented to minimize ecological effects on listed natural populations are described in HGMP sections 7.7, 9.3, 9.16, 9.17, 9.27, 10.9, and 11.1. All juvenile fish released through the program are marked through thermally induced otolith banding or with bland or coded wire tags. Juvenile emigrant trapping has been conducted to assess the productivity of the naturally spawning chinook population in the Dungeness River watershed, and the emigration behavior and survival of hatchery chinook reaching the lower river (WDFW 1997; D. Seiler, WDFW, unpublished juvenile out-migrant trapping data, 1997).

6.2.32.4 Program Performance. The 2000 brood year was the first return of 4 year old hatchery-origin adults to the Dungeness River, and smolt-to-adult survival rate estimates for juveniles released through the program are not yet available (WDFW 2003z). The program appears to be leading to an increase in the number of naturally spawning chinook salmon for the reference TRT population in the Dungeness River watershed (WDFW 2003z; SaSI 2003). NMFS (2003) reported a 1998-2002 geometric mean natural spawner escapement for the Dungeness population of 222 fish. The mean number of natural-origin spawners comprising total escapement for this period is unknown. However, program-origin fish comprised an estimated 90 percent of the total naturally spawning return of 218 fish in 2000 (WDFW 2003z). Natural spawner abundance trend data would indicate that the natural population is barely replacing itself on the short and long term (NMFS 2003). The program is planned to continue for 12 years as a measure to reduce the risk of genetic diversity loss to the Dungeness population that might result from the artificial propagation program (NFRB 1995; WDFW 2001). The water intake structure at Canyon Creek (a tributary used by the Dungeness Hatchery complex) has blocked upstream migration of salmon. WDFW is developing plans to renovate the structure to provide fish passage (WDFW 2003z; WDFW and PSTT 2004). Screening associated with the intake structure for hatchery in the Dungeness River is not in compliance with NMFS screening criteria, and the intake has not been operated since 1999 as a measure to protect natural fish (WDFW 2003z). Other screens associated with water intakes at the hatchery complex are in compliance. WDFW has received funding to renovate the Dungeness River structure to achieve compliance with Federal and state screening requirements.

6.2.32.5 VSP Effects. This chinook conservation hatchery program provides a substantial benefit to the preservation of the Dungeness chinook salmon population, a unique population on the verge of extirpation. The Dungeness population that will likely be important for recovery of the Puget Sound chinook salmon ESU to a viable level. The hatchery population produced by the program likely benefits the abundance, diversity, and spatial structure of the reference Dungeness natural population. Adult fish produced through the program return to natural spawning areas for the source population, and are not collected at Dungeness Hatchery. Total

adult chinook returns to the Dungeness River of 218 in 2001, 453 in 2002, and over 600 in 2003 suggest that juvenile fish production from the program may be helping to improving naturally spawning chinook abundance relative to abundances observed prior to initiation of the hatchery effort. The average adult return for the five years preceding the first supplementation program returns to the river was 116 fish (WDFW 2003z). Measures are applied through the program to maintain the genetic diversity of the propagated population, including maintenance of separate families and factorial mating strategies. The practice of releasing juveniles from the program adjacent to natural spawning areas helps retain natural population spatial structure, especially given the depressed status of the natural population and the likelihood that historically used spawning areas were not accessed prior to supplementation program adult returns. The program's effects on productivity are unknown, but the continuing poor abundance status of the naturally spawning population would suggest that its productivity in the extant natural environment remains poor. It is too early to assess whether contributions by naturally spawning fish are leading to improved productivity. NMFS (2003) reported a short term λ for the composite (hatchery and natural chinook) Dungeness population of 1.09. In developing this estimate, it was assumed that the reproductive success of naturally spawning hatchery fish was equivalent to that of natural fish. Long and short term population trend estimates calculated on all spawners were 1.02 and 1.07, respectively (NMFS 2003).

6.2.33 Elwha Channel Hatchery Chinook

6.2.33.1 Broodstock/Program History. Hatchery chinook salmon releases into the Elwha River started in 1914, but consistent annual releases did not occur until 1953. The Elwha Channel Hatchery facility was built at river mile 2.9 in 1974 and has operated every year since that time for the purpose of supplementing the natural Elwha chinook population (WDFW 2003za). Broodstock collection and juvenile fish production practices have been implemented since initiation of the program to support the production of adult returns to a watershed that has been truncated through placement of two hydroelectric dams. The program will be adjusted to act as the in-river reserve for the Elwha population when dam removal planned for commencement in 2007 leads to lethal silt and debris levels in the river used by the natural population downstream of the dams (NPS 2003).

Broodstock used to establish the current program were collected from the run at large adult chinook return to the Elwha River (WDFW 2003za). The chinook salmon adult return to the hatchery release site is now collected for use as broodstock as volunteers to the hatchery weir and trap. However, the majority of broodstock used to sustain the hatchery program are still collected using seines or gaffs from the 4.8 miles of natural spawning areas accessible to chinook salmon in the Elwha River. Due to poor attraction and trapping capabilities, only a small proportion of annual broodstock needs are met with volunteers into the hatchery trap. Substantial, annual infusions of chinook collected from natural reaches in the Elwha River are required to sustain the hatchery program. The majority (1996-2001 annual average of 83.3 percent) of broodstock needed to sustain the program each year are gaffed or netted from natural river reaches within a 2.5 mile radius upstream and downstream of the hatchery. Hatchery

personnel do not differentiate between hatchery- and natural-origin fish during broodstock collection in the river, which, with the hatchery trap, collect adult chinook across the breadth of the annual return period. The ratios of marked to unmarked fish for both the hatchery trap and fish collected from the river are very similar (WDFW 2003za). These collection practices lead to the production of hatchery progeny that are a composite of returning natural- and hatchery-origin spawners. During the planned dam removal period, a weir spanning the lower Elwha River will be used to trap and collect broodstock (WDFW 2003za). As a conservation hatchery program propagating broodstock directly derived from the native population, the program is considered fully integrated with the extant natural Elwha chinook population.

6.2.33.2 Similarity of Hatchery Origin to Natural Origin Fish. Genetic analyses of Elwha chinook indicate that they are genetically distinct from all other Puget Sound chinook populations (Marshall et al., 1995). The hatchery program collects the majority of annual broodstock from the Elwha River, and the natural and hatchery components of the total Elwha chinook population are completely intermingled (SaSI 2003). The hatchery population is currently listed as protected under the ESA with the natural-origin Elwha population. Hatchery-origin and natural-origin Elwha chinook salmon share identical life history characteristics for the majority of the natural chinook salmon life cycle, including: seaward emigration in the lower Elwha River as subyearling smolts in June; early rearing in eastern Strait of Juan de Fuca nearshore marine areas; emigration into Washington and British Columbia pelagic marine areas; rearing for two to five years from smolt-to-adult size in Northeast Pacific marine waters; migration through British Columbia and Washington marine waters as maturing two to five year old adults in the spring and early summer months; and freshwater entry and spawning in the Elwha River watershed in late August through mid October (WDFW 2003za; SaSI 2003). On the other hand, the hatchery-origin fish are artificially spawned, and their progeny are incubated and reared in a hatchery under controlled conditions for five months, rather than being deposited as eggs in Elwha River gravel reaches and rearing to subyearling smolt size in the natural environment. Monitoring and evaluation of the genetic and ecological effects of the program are ongoing, and data collected will be used to adjust the hatchery program to meet its fish production and conservation objectives (WDFW 2003za; NPS 2003).

6.2.33.3 Program Design. The program is specifically designed to preserve and increase the abundance of the native Elwha chinook population to mitigate for habitat blockage, loss, and degradation associated with hydroelectric dam placement and operation in the watershed. The program is integrated with the extant natural chinook population. Due to the lack of an identifiable mark on hatchery fish, the proportion of hatchery chinook of the total naturally spawning population in the river is unknown. WDFW intends to mass mark fall chinook production from the facility in the near future, with a proportion also receiving coded wire tags. Mass marking of hatchery chinook will allow for evaluations of the program's success in returning spawners to the Elwha River, and smolt-to-adult survival rates for the program.

Best management practices are applied in implementing the program, and most are consistent with measures described for integrated programs in Appendix I, and with conservation hatchery

program practices proposed in Flagg and Nash (1999). The exception is that, given confined and degraded habitat conditions in the river that likely limit natural chinook production, first generation hatchery chinook likely comprise a substantial proportion of the total natural chinook population. Specific measures implemented to minimize adverse genetic, ecological, and demographic effects on listed fish, including those under propagation at the hatchery, are included in the Elwha hatchery HGMP (WDFW 2003za). An effective breeding population size (N_e) of 4,094 (1998-2001) has been maintained. Sections 6, 7, 8, and 9 of the HGMP describe broodstock selection, collection, mating, and juvenile fish rearing measures that will be applied to minimize the risk of within and among population diversity loss to the donor listed population and artificially propagated, chinook salmon population. Measures implemented to reduce ecological effects on the listed natural population are described in HGMP sections 7.7, 9.3, 9.16, 9.17, 9.27, 10.9, and 11.1.

6.2.33.4 Program Performance. Due to the lack of a consistent hatchery fish marking program, an average smolt-to-adult survival rate estimate for juveniles released through the program is not available (WDFW 2003za). Survival data from release to return is limited to a few brood years for which a proportion of hatchery releases were identified with coded wire tags (data from WDFW 2003za). The 1992 brood year releases had an estimated total smolt to age 3 to 6 year adult survival rate of 0.24 percent. Three tag groups were released from the program in brood year 1994. Data collected through 1999 indicated that two subyearling groups released that brood year averaged .09 percent survival through age 5. NMFS (2003) reported a 1998-2002 geometric mean natural spawner escapement for the Elwha population (excluding fish removed for use in the hatchery program) of 688 fish. The mean number of natural-origin spawners comprising total escapement for this period was unknown (NMFS 2003). Hatchery-origin fish are believed by the resource co-managers to comprise the vast majority of naturally spawning chinook (B. Freymond, WDFW, pers. comm., 2003; SaSI 2003). SaSI (2003) reported that the hatchery program is essential for the maintenance of the Elwha population at its present low abundance level. Adult fish produced through the Elwha Channel Hatchery program return to natural spawning areas for the source population, with a low proportion returning to the hatchery broodstock collection facility. The 1995-1999 arithmetic mean number of adult fall chinook salmon collected from the river or at the hatchery for use as broodstock was 1,032 fish (WDFW 2003za). The annual broodstock collection goal for the program is 2,400 adult fish, a total not met for many years due to the depressed abundance status of the total return. The progeny of spawners are released subyearlings from the hatchery near the middle portion of the 4.8 miles of spawning habitat available to the naturally spawning population below Elwha Dam. Natural spawner abundance trend data indicates that the natural population is not replacing itself on the short or long term (NMFS 2003), coincident with hatchery production of adults returning to the watershed and spawning naturally. The program is planned to continue for approximately ten years after the dams are removed on the Elwha River to first preserve the Elwha genome, and then help restore a viable, self-sustaining natural chinook population in the Elwha River (NPS 2003). Water intake screening for the hatchery is in compliance with NMFS screening criteria (WDFW 2003za).

6.2.33.5 VSP Effects. The Elwha Hatchery program preserves the natural Elwha chinook salmon population that is currently limited in abundance, spatial structure and productivity by hydroelectric dams in the watershed. Given its location on the outer reaches of the ESU geographic boundary and its genetic distinctness relative to other populations in the ESU, the Elwha population will likely be important for recovery of the Puget Sound chinook salmon ESU to a viable level. The hatchery population is currently listed as protected under the ESA with its founding natural-origin Elwha population, and with other natural-origin populations in the ESU. The Elwha Hatchery population likely benefits the abundance, diversity, and spatial structure of the reference Elwha natural population. Habitat loss and degradation, and spawner mortality in the river due to disease associated with high water temperatures, have led to chronically low escapements since 1992. Available survival rates for hatchery program fish, and assessments by biologists familiar with the watershed, suggest that adult returns from the hatchery program are sustaining the abundance of the naturally spawning population and are essential for the maintenance of the population at its current low abundance level. Appropriate measures are applied through the hatchery program to maintain the diversity of the propagated population. Broodstock are collected mainly from the mainstem river and randomly over the breadth of the spawner return, a high effective breeding population size has been maintained, and a factorial mating scheme is used during spawning. Spatial structure of the Elwha population has been severely compromised by the construction of dams in the river, and the hatchery program can only be expected to retain the present disrupted spatial structure of the extant natural population. The program's effects on the natural productivity of Elwha chinook are unknown, but the continuing poor abundance status of the naturally spawning population would suggest that its productivity in its severely constricted natural environment remains poor, and decades of contribution of naturally spawning hatchery-origin chinook are not leading to improved natural fish productivity. NMFS (2003) reported a short term λ for the composite (hatchery and natural chinook) Elwha population of 0.95. In developing this estimate, it was assumed that the reproductive success of naturally spawning hatchery fish was equivalent to that of natural fish. Long and short term population trend estimates calculated on all spawners were 0.92 and 0.97, respectively (NMFS 2003).

6.3 CONCLUSION

Existing Status: Threatened
BRT Finding: Threatened
Recommendation: Threatened

6.3.1. ESU Overview

6.3.1.1 History of Populations

An estimated 31 independent chinook salmon populations were historically present in the Puget Sound chinook salmon ESU (BRT 2003). Of the 31 populations, 22 remain extant, and 9 are putatively extinct. Of the 9 extinct chinook salmon populations, 8 were early run populations, or components of populations.

Remaining populations are: North Fork Nooksack River; South Fork Nooksack River; Lower Skagit River; Upper Skagit River; Lower Sauk River; Suiattle River; Upper Sauk River; Cascade River; North Fork Stillaguamish River; South Fork Stillaguamish River; Skykomish River; Snoqualmie River; North Lake Washington; Cedar River; Green/Duwamish River; Puyallup River; White River; Nisqually River; Skokomish River; Mid-Hood Canal; Dungeness River; and Elwha River.

6.3.1.2 Association Between Natural Populations and Artificial Propagation

Natural populations “with minimal genetic contribution from hatchery fish”

Artificial propagation programs for chinook salmon were historically, and are currently, widespread in the Puget Sound region. The fraction of hatchery fish historically contributing to natural spawning in most watersheds has been unknown, but data suggest that few natural population share a low fraction of hatchery-origin fish (BRT 2003). There are presently seven listed natural populations in this ESU that are likely to be subject to minimal or less genetic influence from hatchery-origin fish. These seven populations are: the Lower Skagit River; Upper Skagit River; Lower Sauk River; Upper Sauk River; Upper Cascade River; Suiattle; and South Fork Stillaguamish. Among these seven, the Lower Skagit, Upper Skagit, and Upper Cascade River have associated hatchery populations produced mainly for monitoring and evaluation purposes that, because of their small program sizes or locations, are likely to have minimal genetic influence on the natural populations. Hatchery programs have a substantial genetic influence on each of the remaining 15 chinook salmon populations in the ESU. Included in the latter 15 populations are five (South Fork Nooksack River, Snoqualmie River, North Lake Washington, Cedar River, and Skokomish River) that have no integrated hatchery populations, but are substantially influenced by adult fish produced by isolated hatchery programs located within the watersheds, or within adjacent watersheds, that stray into natural spawning areas used by the natural populations.

Natural^a populations “that are stable or increasing, are spawning in the wild, and have adequate spawning and rearing habitat”^b

The Lower Skagit River, Upper Skagit River, Upper Cascade River, Lower Sauk River, Upper Sauk River, Suiattle River, and South Fork Stillaguamish River natural populations may be considered stable (as determined by estimated long- and short-term abundance trends and short term median population growth rates near or equivalent to 1.0 (BRT 2003)), spawning in the wild, and having adequate spawning habitat. Rearing habitat for the six natural populations in the Skagit River watershed has been compromised by the loss and degradation of lower river delta and estuarine areas essential for the long term viability of those populations.

Mixed (Integrated Programs^c)

Mixed (aggregate natural and hatchery-origin) chinook salmon populations in the ESU are: North Fork Nooksack River; Lower Skagit River; Upper Skagit River; Upper Cascade River; North Fork Stillaguamish River; Skykomish River; Green/Duwanish River; Puyallup River; White River; Nisqually River; Mid-Hood Canal; Dungeness River; and Elwha River. Natural populations that have substantially spawning by stray hatchery fish that are not part of an integrated program are South Fork Nooksack River, Snoqualmie River, North Lake Washington, Cedar River, and Skokomish River.

Hatchery (Isolated^d)

Within ESU hatchery populations that are isolated from extant natural populations and/or watersheds historically supporting self-sustaining chinook salmon populations are: Lummi Bay Fall Chinook; Glenwood Springs Fall Chinook; Samish River Fall Chinook; Tulalip Bay Spring Chinook; Tulalip Bay Fall Chinook; Issaquah Fall Chinook; Portage Bay Fall Chinook; Grovers Creek Fall Chinook; Garrison Spring Fall Chinook; Chambers Creek Fall Chinook; Minter Creek Fall Chinook; Tumwater Falls Fall Chinook; George Adams Fall Chinook; Rick’s Pond Fall Chinook; Hoodspout Fall Chinook; and Big Beef Creek Fall Chinook.

^a See HLP for definition of natural, mixed and hatchery populations

^b HLP Point 3

^c Integrated programs follow practices designed to promote and protect genetic diversity and only use fish from the same local population for broodstock (both natural-origin fish, whenever possible, and hatchery-origin fish derived from the same local population and included in the ESU). Programs operated to protect genetic diversity in the absence of natural-origin fish (e.g., captive broodstock programs and the reintroduction of fish into vacant habitat) are considered “integrated.”

^d Isolated programs do not follow practices designed to promote or protect genetic diversity. Fish that are reproductively isolated are more likely to diverge genetically from natural populations included in the ESU and to be excluded themselves from the ESU.

6.3.2. Summary of ESU Viability:

6.3.2.1 Abundance. Table 4 summarizes recent year abundance information for extant populations within the ESU, including the estimated total number of naturally spawning fish, and the number of within ESU hatchery-origin fish contributing to total natural spawning or escapement. Historical equilibrium abundance estimates derived for each population using the Ecosystem Diagnosis and Treatment (EDT) method provide perspective regarding the abundance status of the populations relative to estimated historical abundance levels. Estimated natural-origin returns and the total number of natural spawners (i.e., the combination of natural-origin and hatchery-origin chinook included in the ESU) have increased since 1999 when the ESU was listed as threatened. However, average total (natural plus hatchery-origin chinook) escapements to natural spawning areas for the most recent ten years remain well below historical equilibrium abundance estimates derived for each population (Table 4).

6.3.2.2 Productivity. The highest risk factor for this ESU is low productivity of the extant naturally spawning populations (BRT 2003). Naturally spawning chinook salmon originating from hatchery programs operating within the ESU do not appear to have benefited the productivity of any natural populations. Population abundance trends have remained stable just at the replacement level, or are decreasing coincident with, in some cases, many decades of natural spawning by hatchery-origin fish.

6.3.2.3 Spatial Structure. Population spatial structure within the Puget Sound chinook salmon ESU has benefited from integrated hatchery programs directed at preserving and restoring natural populations. Certain harvest augmentation programs have also likely benefited spatial structure by increasing the numbers of naturally spawning chinook salmon using spawning reaches where chinook were historically present. Hatchery programs of both types (conservation and harvest augmentation) are reintroducing chinook salmon into historically used and/or unoccupied habitats that have been blocked to salmon migration by hydroelectric dams or natural features. Most programs operate weirs, traps, and water intake structures in a manner that does not block or hinder access to natural spawning areas by migrating natural salmon populations. Hatchery programs in the region are seeding areas upstream of fish collection weirs by passing appropriate numbers of chinook salmon upstream to spawn naturally. Programs that operate structures that block salmon migration are implementing actions designed to provide for upstream access.

6.3.2.4 Diversity. The North Fork Nooksack River, North Fork Stillaguamish River, White River, Dungeness River, and Elwha River integrated conservation hatchery programs are preserving early spawning chinook salmon populations that are important components of total population diversity remaining within the ESU. The historical and continued widespread use of transplanted Green River hatchery stock in or adjacent to watersheds where natural populations are present remains a substantial risk factor to the preservation of genetic diversity remaining among chinook populations within the ESU.

6.3.3. Artificial Propagation Record

6.3.3.1 Experience with Integrated Programs. Integrated conservation-directed hatchery programs have been operated in the Puget Sound region for one to five decades: Kendall Creek - 25 years; Harvey Creek/Whitehorse Springs - 24 years; White River programs - 12-30 years; Dungeness - 12 years; and Elwha Channel - 51 years.

Integrated harvest augmentation hatchery programs have operated in the region for a longer period, with Soos Creek Hatchery beginning a year to year program 103 years ago. Most of these program have produced adult fish for harvest purposes for several decades.

6.3.3.2 Are Integrated Programs Self-Sustaining. Smolt-to-adult survival rate data presented in HGMPs for individual Puget Sound region integrated chinook salmon hatchery programs indicates that the programs are operating above the replacement rate.

6.3.3.3 Certainty that Integrated Programs will Continue to Operate. Integrated conservation programs operating in the region have fairly stable funding sources, and are fairly certain to continue under current resource management agreements and strategies. However, several of these programs include plans to terminate operations after a set period, in accordance with genetic diversity preservation measures or in response to improved status with respect to abundance for target natural populations. Integrated harvest augmentation program also have fairly stable funding sources and are fairly certain to continue. These programs are agreed strategies under the *U.S. v. Washington* fishery management framework and in accordance with mitigation agreements, to provide adult chinook salmon for harvest in response to lost natural fish production associated with habitat loss, blockage, and degradation in the region. Monitoring and evaluation actions included in the hatchery plans support the ability to adjust each integrated hatchery program to meet conservation and fish production objectives.

6.3.4. Summary of Overall Extinction Risk Faced by the ESU

Most populations in the ESU remain small relative to historical run sizes, and short and long term abundance trends are stable (at the replacement level) or declining. Inclusion of hatchery-origin chinook in escapement abundance estimates does not lead to total escapements approaching historical abundance estimates. The productivity of extant naturally spawning populations does not appear to have benefited from up to many decades of purposeful or inadvertent (as strays) augmentation by naturally spawning hatchery-origin fish. Conservation programs operating in the region are preserving genetic diversity remaining in the ESU by propagating unique early timed chinook populations that would likely have become extinct without the hatchery programs. However, this benefit to genetic diversity may be offset by risks of reduction in among population diversity posed by the continued widespread use of hatchery-origin fall chinook originating from only one (Green/Duwamish River) of the 22 extant populations. ESU spatial structure may benefit from the collective hatchery programs operating

in Puget Sound as a result of enhanced natural spawner abundances leading to use of historical natural spawning habitat and release of natural and hatchery-origin chinook upstream of man-made or natural barriers to seed unoccupied natural spawning areas.

Table 6.4. Puget Sound chinook salmon.

Return Year	NF/MF Nooksack			SF Nooksack			Lower Skagit			Upper Skagit			Upper Cascade		
	Natural-origin escapement	Hatchery-origin escapement	Total escapement	Natural-origin escapement	Hatchery-origin escapement	Total escapement	Natural-origin escapement	Hatchery-origin escapement	Total escapement	Natural-origin escapement	Hatchery-origin escapement	Total escapement	Natural-origin escapement	Hatchery-origin escapement	Total escapement
2/															
1978							2987	288	3,275	8448	455	8,903			
1979							3829	319	4,148	7841	465	8,306			
1980							4921	1086	6,007	12399	1326	13,725			
1981							2348	500	2,848	4233	576	4,809			
1982							1932	884	2,816	6845	1022	7,867			
1983							3151	1050	4,201	5197	1142	6,339			
1984	45	0	45	188	0	188	2306	1595	3,901	9642	1793	11,435	113	0	113
1985	255	0	255	445	0	445	1686	254	1,940	13801	551	14,352	100	0	100
1986	224	0	224	170	0	170	4584	806	5,390	12181	1044	13,225	380	0	380
1987	179	0	179	248	0	248	2635	328	2,963	5982	442	6,424	200	0	200
1988 3/	452	893	1,345	233	886	1,119	2339	1310	3,649	8077	1473	9,550	133	0	133
1989	300	501	801	606	497	1,103	1454	426	1,880	4781	522	5,303	218	17	235
1990	10	115	125	142	114	256	3705	1325	5,030	11793	1561	13,354	269	303	572
1991	107	161	268	365	160	525	1510	927	2,437	3656	997	4,653	135	308	443
1992	493	1,084	1,577	103	1072	1,175	1331	2223	3,554	5548	2337	7,885	205	386	591
1993	446	1,455	1,901	235	1443	1,678	942	1192	2,134	4654	1289	5,943	168	208	376
1994	45	587	632	118	582	700	884	4033	4,917	4565	4107	8,672	173	1574	1,747
1995	228	845	1,073	290	836	1,126	666	2581	3,247	5948	2676	8,624	225	489	714
1996	538	1,398	1,936	203	1138	1,341	1521	1205	2,726	7989	1193	9,182	208	1080	1,288
1997	621	2,163	2,784	180	1757	1,937	409	3	412	4168	68	4,236	308	960	1,268
1998	366	1,605	1,971	157	1351	1,508	2388	0	2,388	11761	270	12,031	323	1138	1,461
1999 4/	911	3,693	4,604	166	429	595	1043	0	1,043	3586	107	3,693	83	1126	1,209
2000	1,364	2,115	3,479	284	351	635	3262	24	3,286	13092	277	13,369	273	3159	3,432
2001	4,057	9,179	13,236	267	456	723	2606	64	2,670	10084	447	10,531	625	1109	1,734
2002	4,671	10,099	14,771	289	1919	2,208	4866	120	4,986	13815	612	14,427	340	1569	1,909
Historical Abundance Estimate 1/			26,000			13,000			22,000			35,000			1,700
All Years															
Arithmetic Means	806	1,889	2,695	247	684	930	2,112	969	3,274	8,164	1,146	9,074	236	707	942
% Natural			29.9%			26.5%			64.5%			90.0%			25.0%
% Hatchery			70.1%			73.5%			29.6%			12.6%			75.0%
Mean % Historical			10.4%			7.2%			14.9%			25.9%			55.4%
Post Listing (1999-)															
Arithmetic Means	2,751	6,272	9,022	252	789	1,040	2,944	52	2,996	10,144	361	10,505	330	1,741	2,071
% Natural			30.5%			24.2%			98.3%			96.6%			15.9%
% Hatchery			69.5%			75.8%			1.7%			3.4%			84.1%
Mean % Historical			34.7%			8.0%			13.6%			30.0%			121.8%

Notes: Data from BRT Puget Sound Chinook Salmon ESU Status Review Table A.2.4.2. "Abundance of natural spawners, estimates of the fraction of hatchery fish in natural escapements, and estimates of historical capacity of Puget Sound streams (Puget Sound TRT, unpublished data and Puget Sound co-managers).

1/ EDT model estimate of historical chinook salmon population abundance.

2/ Hatchery origin chinook escapement includes estimated escapement to natural spawning areas and escapement to hatcheries.

3/ Marblemount Hatchery escapement data for spring chinook from WDFW March, 2003 HGMP.

4/ South Fork Nooksack population data for 1999-2002 from the Nooksack and Lummi Tribes, March 1, 2004.

Table 4 (continued). Puget Sound chinook salmon.

Return Year	Lower Sauk			Upper Sauk			Suiattle			North Fork Stillaguamish			South Fork Stillaguamish		
	Natural-origin escapement	Hatchery-origin escapement	Total escapement	Natural-origin escapement	Hatchery-origin escapement	Total escapement	Natural-origin escapement	Hatchery-origin escapement	Total escapement	Natural-origin escapement	Hatchery-origin escapement	Total escapement	Natural-origin escapement	Hatchery-origin escapement	Total escapement
2/															
1978	1640	0	1,640	404	0	404	416	0	416	1018	0	1,018	214	0	214
1979	1636	0	1,636	411	0	411	281	0	281	861	0	861	181	0	181
1980	2738	0	2,738	590	0	590	1094	0	1,094	678	0	678	143	0	143
1981	1702	0	1,702	447	0	447	673	0	673	520	0	520	110	0	110
1982	1133	0	1,133	277	0	277	476	0	476	638	0	638	135	0	135
1983	375	0	375	202	0	202	352	0	352	320	0	320	67	0	67
1984	680	0	680	238	0	238	372	0	372	309	0	309	65	0	65
1985	515	0	515	1818	0	1,818	716	0	716	1148	0	1,148	261	0	261
1986	1143	0	1,143	735	0	735	806	0	806	980	0	980	297	0	297
1987	792	0	792	815	0	815	729	0	729	1065	2	1,067	256	0	256
1988 3/	1052	0	1,052	870	0	870	740	0	740	516	11	527	201	0	201
1989	449	0	449	668	0	668	514	0	514	537	63	600	274	0	274
1990	1294	0	1,294	557	0	557	685	0	685	575	169	744	267	0	267
1991	658	0	658	747	0	747	464	0	464	1331	401	1,732	301	0	301
1992	469	0	469	580	0	580	201	0	201	486	146	632	294	0	294
1993	205	0	205	323	0	323	292	0	292	583	312	895	345	0	345
1994	100	1	101	130	0	130	167	0	167	667	317	984	287	0	287
1995	263	0	263	190	0	190	440	0	440	599	216	815	223	0	223
1996	1103	0	1,103	408	0	408	435	0	435	993	383	1,376	251	0	251
1997	295	0	295	305	0	305	428	0	428	930	440	1,370	226	0	226
1998	460	0	460	290	0	290	473	0	473	1292	777	2,069	248	0	248
1999 4/	295	0	295	180	0	180	208	0	208	845	435	1,280	253	0	253
2000	576	0	576	273	0	273	360	0	360	1403	599	2,002	243	0	243
2001	1103	5	1,108	543	0	543	688	0	688	1066	500	1,566	283	0	283
2002	910	0	910	460	0	460	265	0	265	1253	595	1,848	335	1	336
Historical Abundance Estimate 1/			7,800			4,200			830			24,000			20,000
All Years															
Arithmetic Means	651	0	864	533	0	498	473	0	491	873	282	1,039	258	0	230
% Natural			75.3%			107.0%			96.3%			84.0%			112.1%
% Hatchery			0.0%			0.0%			0.0%			27.2%			0.0%
Mean % Historical			11.1%			11.9%			59.2%			4.3%			1.2%
Post Listing (1999-)															
Arithmetic Means	721	1	722	364	0	364	380	0	380	1,142	532	1,674	279	0	279
% Natural			99.8%			100.0%			100.0%			68.2%			99.9%
% Hatchery			0.2%			0.0%			0.0%			31.8%			0.1%
Mean % Historical			9.3%			8.7%			45.8%			7.0%			1.4%

Notes: Data from BRT Puget Sound Chinook Salmon ESU Status Review Table A.2.4.2. "Abundance of natural spawners, estimates of the fraction of hatchery fish in natural escapements, and estimates of historical capacity of Puget Sound streams (Puget Sound TRT, unpublished data and Puget Sound co-managers).

1/ EDT model estimate of historical chinook salmon population abundance.

2/ Hatchery origin chinook escapement includes estimated escapement to natural spawning areas and escapement to hatcheries.

3/ Marblemount Hatchery escapement data for spring chinook from WDFW March, 2003 HGMP.

4/ South Fork Nooksack population data for 1999-2002 from the Nooksack and Lummi Tribes, March 1, 2004.

Table 4 (continued). Puget Sound chinook salmon.

Return Year	Skykomish			Snoqualmie			North Lake Washington			Cedar			Green/Duwamish		
	Natural-origin escapement	Hatchery-origin escapement	Total escapement	Natural-origin escapement	Hatchery-origin escapement	Total escapement	Natural-origin escapement	Hatchery-origin escapement	Total escapement	Natural-origin escapement	Hatchery-origin escapement	Total escapement	Natural-origin escapement	Hatchery-origin escapement	Total escapement
2/															
1978	5849	3548	9,397	1959	121	2,080				890	0	890	3304	11246	14,550
1979	5277	1933	7,210	432	1645	2,077				1243	0	1,243	9704	23959	33,663
1980	5221	4200	9,421	1278	3576	4,854				1360	0	1,360	7743	19466	27,209
1981	2408	4407	6,815	922	3743	4,665				624	0	624	3606	14571	18,177
1982	3690	2753	6,443	808	2345	3,153				763	0	763	1840	5646	7,486
1983	2813	1409	4,222	1724	1206	2,930	544	6751	7,295	788	0	788	3679	4618	8,297
1984	2389	1419	3,808	1095	1240	2,335	354	3577	3,931	898	0	898	3353	6507	9,860
1985	3580	1146	4,726	1150	993	2,143	183	3189	3,372	766	0	766	2908	6800	9,708
1986	3377	1189	4,566	1157	1139	2,296	528	3396	3,924	942	0	942	4792	15526	20,318
1987	3834	1408	5,242	855	1213	2,068	498	2716	3,214	1540	0	1,540	10338	21386	31,724
1988 3/	4004	1385	5,389	509	1198	1,707	233	1567	1,800	559	0	559	7994	17739	25,733
1989	2221	1500	3,721	952	1255	2,207	453	3585	4,038	558	0	558	11515	23014	34,529
1990	2932	1615	4,547	1277	1627	2,904	318	5098	5,416	469	0	469	7035	12464	19,499
1991	2192	1067	3,259	628	1116	1,744	153	1684	1,837	508	0	508	10548	10304	20,852
1992	2002	824	2,826	706	656	1,362	265	1254	1,519	525	0	525	5267	7655	12,922
1993	1653	1513	3,166	2366	1061	3,427	89	3475	3,564	156	0	156	2476	3211	5,687
1994	2898	3013	5,911	728	2096	2,824	436	3923	4,359	452	0	452	4078	6592	10,670
1995	2791	4963	7,754	385	4181	4,566	249	2582	2,831	681	0	681	7939	10265	18,204
1996	3819	5965	9,784	1032	4775	5,807	33	2146	2,179	303	0	303	6026	11760	17,786
1997	2355	3301	5,656	1937	3629	5,566	67	5265	5,332	227	0	227	9967	17509	27,476
1998	4412	7496	11,908	1892	5503	7,395	265	7314	7,579	432	0	432	7312	11822	19,134
1999 4/	3455	7307	10,762	1344	7016	8,360	537	3507	4,044	241	0	241	11025	13240	24,265
2000	4665	7528	12,193	1427	5739	7,166	227	1668	1,895	120	0	120	6170	8107	14,277
2001	4575	4137	8,712	3589	3750	7,339	459	10451	10,910	810	0	810	7975	14876	22,851
2002	4325	1713	6,038	2895	451	3,346	268			369			13950	14409	28,359
Historical Abundance Estimate 1/			51,000			33,000			N/A			N/A			N/A
All Years															
Arithmetic Means	3,236	3,078	6,539	1,364	2,560	3,773	296	3,689	3,986	556	0	661	7,404	12,273	19,329
% Natural			49.5%			36.2%			7.4%			84.1%			38.3%
% Hatchery			47.1%			67.9%			92.5%			0.0%			63.5%
Mean % Historical			12.8%			11.4%			N/A			N/A			N/A
Post Listing (1999-)															
Arithmetic Means	4,255	5,171	9,426	2,314	4,239	6,553	373	5,209	5,616	385	0	390	9,780	12,658	22,438
% Natural			45.1%			35.3%			6.6%			98.6%			43.6%
% Hatchery			54.9%			64.7%			92.7%			0.0%			56.4%
Mean % Historical			18.5%			19.9%			N/A			N/A			N/A

Notes: Data from BRT Puget Sound Chinook Salmon ESU Status Review Table A.2.4.2. "Abundance of natural spawners, estimates of the fraction of hatchery fish in natural escapements, and estimates of historical capacity of Puget Sound streams (Puget Sound TRT, unpublished data and Puget Sound co-managers).

1/ EDT model estimate of historical chinook salmon population abundance.

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3/ Marblemount Hatchery escapement data for spring chinook from WDFW March, 2003 HGMP.

4/ South Fork Nooksack population data for 1999-2002 from the Nooksack and Lummi Tribes, March 1, 2004.

Table 4 (continued). Puget Sound chinook salmon.

Return Year	White			Puyallup			Nisqually			Skokomish		
	Natural-origin escapement	Hatchery-origin escapement WRH	Total escapement	Natural-origin escapement	Hatchery-origin escapement	Total escapement	Natural-origin escapement	Hatchery-origin escapement	Total escapement	Natural-origin escapement	Hatchery-origin escapement	Total escapement
2/												
1978	140	0	140	962	837	1,799	178			164		
1979	72	0	72	2359	2553	4,912	1665	0	1,665	1251		
1980	61	0	61	2553	2344	4,897	1124	0	1,124	479		
1981	175	0	175	518	2264	2,782	439	0	439	117		
1982	20	0	20	851	1096	1,947	848	28	876	248		
1983	21	28	49	1184	1959	3,143	1066	223	1,289	1007		
1984	7	45	52	1258	807	2,065	313	163	476	1394		
1985	27	35	62	1147	1438	2,585	112	50	162	2974		
1986	6	186	192	740	977	1,717	300	205	505	2643		
1987	117	144	261	925	780	1,705	85	117	202	2112	3337	5,449
1988 3/	127	504	631	1332	1128	2,460	1342	738	2,080	2666	4930	7,596
1989	83	355	438	2442	762	3,204	2332	794	3,126	1204	2556	3,760
1990	275	242	517	3515	1651	5,166	994	700	1,694	642	2186	2,828
1991	194	232	426	1702	1273	2,975	953	201	1,154	1719	3068	4,787
1992	406	633	1,039	3034	1718	4,752	106	311	417	825	294	1,119
1993	409	539	948	1999	1546	3,545	1655	1372	3,027	960	612	1,572
1994	392	835	1,227	1328	2533	3,861	1730	2104	3,834	657	495	1,152
1995	605	1079	1,684	2344	2023	4,367	817	3623	4,440	1398	5196	6,594
1996	628	997	1,625	2111	2499	4,610	606	2701	3,307	995	3100	4,095
1997	402	1207	1,609	1110	3434	4,544	340	3251	3,591	452	1885	2,337
1998	316	781	1,097	1711	3484	5,195	834	4067	4,901	1177	5584	6,761
1999 4/	553	997	1,550	1988	3464	5,452	1399	13481	14,880	1692	8227	9,919
2000	1523	840	2,363	1193	1850	3,043	1253	4923	6,176	926	4033	4,959
2001	2002	1325	3,327	1915	2576	4,491	1079	0	1,079	1913	8816	10,729
2002	803			1590	0	1,590	1542			1479		
Historical Abundance Estimate 1/			N/A			33,000			18,000			N/A
All Years												
Arithmetic Means	467	610	815	1,757	1,786	3,472	936	2,156	2,628	1,465	3,621	4,910
% Natural			57.3%			50.6%			35.6%			29.8%
% Hatchery			74.8%			51.4%			82.0%			73.7%
Mean % Historical			N/A			10.5%			14.6%			N/A
Post Listing (1999-)												
Arithmetic Means	1,220	1,054	2,413	1,672	1,973	3,644	1,318	6,135	7,378	1,503	7,025	8,536
% Natural			50.6%			45.9%			17.9%			17.6%
% Hatchery			43.7%			54.1%			83.1%			82.3%
Mean % Historical			N/A			11.0%			41.0%			N/A

Notes: Data from BRT Puget Sound Chinook Salmon ESU Status Review Table A.2.4.2. "Abundance of natural spawners, estimates of the fraction of hatchery fish in natural escapements, and estimates of historical Puget Sound streams (Puget Sound TRT, unpublished data and Puget Sound co-managers).

1/ EDT model estimate of historical chinook salmon population abundance.

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3/ Marblemount Hatchery escapement data for spring chinook from WDFW March, 2003 HGMP.

4/ South Fork Nooksack population data for 1999-2002 from the Nooksack and Lummi Tribes, March 1, 2004.

Table 4 (continued). Puget Sound chinook salmon.

Return Year	Mid Hood Canal			Dungeness			Elwha		
	Natural-origin escapement	Hatchery-origin escapement	Total escapement	Natural-origin escapement	Hatchery-origin escapement	Total escapement	Natural-origin escapement	Hatchery-origin escapement	Total escapement
2/									
1978	52	0	52						
1979	638	0	638						
1980	244	0	244						
1981	146	0	146						
1982	127	0	127						
1983	513	0	513						
1984	710	0	710						
1985	1516	0	1,516						
1986	45	0	45	238	0	238	855	1285	2,140
1987	97	0	97	100	0	100	1642	1283	2,925
1988 3/	127	0	127	335	0	335	5228	2089	7,317
1989	113	0	113	88	0	88	3035	1135	4,170
1990	81	0	81	310	0	310	1644	586	2,230
1991	86	0	86	163	0	163	1642	970	2,612
1992	96	0	96	158	0	158	479	97	576
1993	112	0	112	43	0	43	633	165	798
1994	384	0	384	65	0	65	163	365	528
1995	103	0	103	163	0	163	524	145	669
1996	91	0	91	183	0	183	364	214	578
1997	193.5	0	194	50	0	50	1578	318	1,896
1998	287	0	287	110	0	110	633	138	771
1999 4/	762	0	762	75	0	75	813	117	930
2000	438	0	438	218	0	218	715	223	938
2001	322	0	322	453	0	453	643	1660	2,303
2002	95	0	95	663			650		
Historical Abundance Estimate 1/			4,700			8,100			N/A
All Years									
Arithmetic Means	298	0	295	201	0	172	1,249	674	1,961
% Natural			100.9%			116.8%			63.7%
% Hatchery			0.0%			0.0%			34.4%
Mean % Historical			6.3%			2.1%			N/A
Post Listing (1999-)									
Arithmetic Means	404	0	404	352	0	249	705	667	1,390
% Natural			100.0%			141.7%			50.7%
% Hatchery			0.0%			0.0%			48.0%
Mean % Historical			8.6%			3.1%			N/A

Notes: Data from BRT Puget Sound Chinook Salmon ESU Status Review Table A.2.4.2. "Abundance of natural spawners, estimates of the fraction of hatchery Puget Sound streams (Puget Sound TRT, unpublished data and Puget Sound co-managers).

1/ EDT model estimate of historical chinook salmon population abundance.

2/ Hatchery origin chinook escapement includes estimated escapement to natural spawning areas and escapement to hatcheries.

3/ Marblemount Hatchery escapement data for spring chinook from WDFW March, 2003 HGMP.

4/ South Fork Nooksack population data for 1999-2002 from the Nooksack and Lummi Tribes, March 1, 2004.

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